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Teachers, students, STEM beliefs and outcomes

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Abstract

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by

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Theory suggests that beliefs are a critical component of student success in the STEM fields. This dissertation presents three analytic chapters that explore student and teacher beliefs and seeks to understand why some students are more successful in the STEM fields while others are not. First, this dissertation examines the relationship between student beliefs pertaining to math, including confidence, mindset, and anxiety with a large national sample of ninth grade students. Results show mindset can be broken up into two distinct factors, a more general belief referring to students' mindset about their intelligence in general, and a more domain specific belief, math mindset, which is the students' belief about their math intelligence as malleable or innate. Additionally, both general and math mindset are distinctly different than math confidence and math anxiety. Moreover, these findings contribute to our understanding of the relationship regarding gender and these beliefs, as girls endorse more fixed math mindset, have less math confidence, and more math anxiety than boys, with the biggest gender gap occurring in math anxiety, which has potential implications for women's underrepresentation in STEM fields. Secondly, this dissertation examines teacher beliefs with a large nationally representative group of high school math teachers, as well as the relationship of these beliefs to their pedagogical practices. On average high school math

teachers tend to agree slightly with deficit views and male teachers and teachers who have taught less than 16 years have stronger deficit views of students. Further, teachers who have stronger deficit beliefs are more likely to use reform practices in their classroom, which may have implications for students' learning and ultimately their decision to enter into STEM. The last analytic chapter examines the relationship between math teachers' beliefs and students' academic outcomes in math. This chapter finds that net of control variables, being taught by a teacher with a higher level of endorsement of deficit beliefs is related to a decrease in students' 9^{th} grade math GPA. This effect applies equally to all students; surprisingly, teacher deficit views are not more harmful for students coming from underserved backgrounds.

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Introduction

Currently, there is a national discussion about the shortage of workers in certain STEM (Science, Technology, Engineering and Mathematics) fields such as engineering (nuclear, electrical, petroleum), materials science, cyber-security, intelligence, data science, and software development (Xue & Larson, 2015). This coupled with PISA international tests results indicating that the United States ranks 29th in math and 22nd in science among industrialized countries, has spurred the United States government to make STEM education a national priority (Holdren, Marrett, & Suresh, 2013). Former President Obama vowed the United States would "move from the middle to the top of the pack in science and math" and create workers for these growing fields, by making sure all students are literate in math and science for the changing world (Holdren, Marret, & Suresh, 2013). As part of the call to make all students literate and critical thinkers in STEM fields, policy makers and researchers have paid particular attention to ways to increase students' interest and engagement with STEM fields during the K-12 years, particularly those who are currently under-represented, and thus have focused on the critical role of teachers in promoting students' STEM outcomes.

Background

What does it take to be successful in STEM fields?

Research shows that one of the strongest predictors of students' decisions to enter STEM college fields and occupations is prior achievement, as those who do well are more likely to enter into these fields due to positive past experiences. Students who take advanced math and science courses (such as pre-calculus and calculus) in high school, have high math and science academic grades, and have high performance on the quantitative portion of standardized tests such as the SAT are likely to enter into STEM majors in college (Ellington, 2006; Ethington &Wolfle, 1988; Maple & Stage, 1991; Wang, 2013). However, both theory and the empirical socio-psychological research also recognize that students' beliefs play a powerful role in choosing and persisting in the STEM fields (Betz & Hackett, 1983; Dweck & Master, 2008; Eccles et al., 1983). For example, research suggests confidence is one of the most powerful predictors of academic achievement (Multon, Brown & Lent, 1991; Pajares & Graham, 1999; Pajares & Miller, 1994), course taking (Correll, 2001), majoring in STEM (Bandura et al., 2001; Betz & Hackett, 1983; Correll, 2001; Eccles & Wang, 2015; Hackett, 1985; Hackett & Betz, 1989; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014), as well as persistence in the STEM fields (Cech, Rubineau, Silbey, & Seron, 2011; Lent, Brown & Larkin, 1984; Multon, Brown & Lent, 1991). Further, research also suggests that mindset influences achievement and persistence (Aronson, Fried, & Good, 2002; Blackwell et al., 2007; Dai & Cromley, 2014; Good, Aronson, & Inzlicht, 2003; Heyman, Martyna, & Bhatia, 2002; Yeager et al., 2016).

Moreover, Eccles' Expectancy Value Theory (Eccles et al., 1983) theorizes students are less likely to enter STEM fields if they do not believe they can succeed in these fields. Student beliefs are informed from their previous socialization experiences, societal roles, and prevalent cultural stereotypes (Eccles, 2011). These outside messages shape students' beliefs about their potential for learning and success, which then may deter certain groups of students from entering into the STEM fields (Eccles, 2011).

Therefore, it is critical to understand students' beliefs, especially in early adolescence as research suggests the decision to major in science and engineering fields begins well before college and as early as in middle and high school (Ethington & Wolfle,1988; Legewie & DiPrete, 2014; Maple & Stage, 1991; Wang, 2013). Therefore, adolescence is a decisive time as this period lays the foundation for choosing likely majors. Further examining students' beliefs as well as how these beliefs differ across groups will help us to better understand why some students are more likely to enter into the STEM fields.

Additionally, Eccles' Expectancy Value Theory stresses the importance of socializers in forming children's beliefs and posits a complex relationship between students, socializers, beliefs and outcomes (Eccles et al., 1983). Particularly important are teachers' beliefs as students spend most of their day in school. Teachers' beliefs reflect their thoughts about learning, the role of schooling, cultural milieu, as well as the stereotypes they hold and what they expect of certain groups of students (Pajares, 1992). Teachers' transmit their beliefs about their students through their actions, their engagement with students, and words. Yet little is known about high school math teachers' beliefs as the majority of work examines elementary and pre-service teachers. Further, teachers' beliefs influence their teaching strategies and potentially their pedagogical practices used in the classroom (Tschannen-Moran, Hoy, & Hoy, 1998; Woolfolk & Hoy, 1990). These teacher beliefs and classroom practices may have implications for students' beliefs about their abilities, potential student outcomes, and may help us disentangle why certain students do not enter into the STEM fields. Therefore, teacher beliefs and their relationship to classroom practices as well as teacher beliefs and their relationship to students' outcomes must be studied, especially at the high school level.

Therefore, this dissertation will focus on student beliefs during adolescence, teacher beliefs, and the relationship between them to help explain STEM outcomes. This dissertation seeks to tie together the socio-psychological literature and the educational literature and will contribute to the existing literature in three ways. First, this dissertation will examine the relationship between different types of student beliefs pertaining to math, including their confidence, mindset, and anxiety with a large national sample of ninth grade students. Secondly, this dissertation will contribute to the literature by examining teacher beliefs with a large nationally representative group of high school math teachers, as well as the relationship of these beliefs to their pedagogical practices. Last, this study will examine the relationship between math teachers' beliefs and students' academic outcomes in math.

Overview of the Analytic Chapters

The first analytic chapter will examine a large nationally representative group of 9^{th} graders surveyed as part of the National Mindset Study and the beliefs they hold regarding mindset (both general and math specific), math confidence, and math anxiety. Math confidence is a person's beliefs in her perceived math capabilities of how she will, currently or in the future, perform in math. General mindset is defined as the belief a person holds about his intelligence as being innate or malleable. Math mindset is the belief a person holds about his math intelligence being innate or malleable and math anxiety is the apprehension one feels about working on math. The literature is not clear about the relationship between them and no studies reviewed examined the relationship between all four of them. Further, this chapter will consider how gender predicts each of these beliefs, as well as the relationship between them. This chapter makes a new contribution since it will be the first national study examining these relationships, as there are currently only small studies with specialized samples concerning gender and its relationship to mindset.

In the second analytic chapter, teacher beliefs will be examined. As the Eccles' Expectancy Value Theory (Eccles et al., 1983) posits socializers are also a critical component of students' beliefs. Since students spend a majority of their day in schools, teachers are important socializers as they interact with students throughout the day and potentially impact students' beliefs through student interactions and pedagogical practices in the classroom. Therefore, it is important to examine high school math teachers' beliefs as well as their pedagogical practices. Yet, there is a dearth of literature on secondary teachers' beliefs, as most literature comes from elementary or pre-service teachers. Thus, the second analytic chapter will examine the characteristics of high school math teachers and their endorsement of deficit views of students' capability to learn. It will also examine if these deficit beliefs predict the use of less reform practices in the classroom, using a large sample of high school math teachers from the High School Longitudinal Study of 2009.

The last analytic chapter examines the relationship between teachers' deficit beliefs and student outcomes using a nationally representative sample of 9th grade students and their 9th grade math teachers from the High School Longitudinal Study of

2009. Even though theory suggests a relationship between teachers' and students' outcomes, there is a disconnect between theory and the empirical research as few studies examine the relationship teacher's deficit beliefs and student's math outcomes. Much of the existing literature examines students' own beliefs in relation to their outcomes, examines sources of students' beliefs separately, or examines teachers' beliefs without considering student outcomes. By looking at the separate pieces, the full relationship between teachers' beliefs and students' math outcomes cannot be established. Therefore, this chapter will bring a new contribution to the literature by examining the relationships between teachers' deficit beliefs and students' math grades with a large national sample. Additionally, it will consider if teachers' deficit belief are more detrimental for students from underserved backgrounds.

Chapter 1: Examining Connections between Confidence, Math Anxiety, and Mindset: A Focus on High School Students

For the last several decades policy makers and researchers have paid particular attention to attracting and retaining women and girls to STEM fields due to patterns of inequality. For example, women earn fewer degrees in computer science (18.2%), engineering (19.2%), and physics (19.1%) compared to men (Falkenheim & Hale, 2015). This inequity remains a continuing problem in both education and the labor force as it limits women's career choices. Women hold less than 25% of the overall STEM jobs available, yet they make up almost half of the United States work force (Beede et al., 2011). Societal effects from the disparity are also felt. Economic consequences include reduced future economic potential due to fewer scientific and technological advancements and a reduced workforce unable to sustain advancement. Further, this disparity reduces women's potential lifetime earnings and perpetuates gender stereotypes and the pay gap between men and women (Beede et al., 2011).

Given this national landscape, how do we attract young women to enter into the STEM fields and ultimately STEM occupations? The literature suggests the decision to enter in a STEM field begins in adolescence, before a student reaches college (Ethington & Wolfle, 1988; Legewie & DiPrete, 2014; Maple & Stage, 1991; Wang, 2013). And while one of the strongest predictors for entry into STEM majors and occupations is prior achievement (Ellington, 2006; Ethington &Wolfle, 1988; Maple & Stage, 1991; Wang, 2013), girls have higher math and science grades than boys (Buchmann & DiPrete, 2006;

Hyde & Linn, 2006; Hyde et al., 2008; Riegle-Crumb et al., 2012; Xie & Shauman 2003), and comparable math and science coursework (Kena et al., 2016; Riegle-Crumb et al., 2012); thus the gender gap in pursuing STEM fields is clearly not due to gaps in prior achievement. Instead, the most promising explanations for the gender gap come from the socio-psychological literature, which recognizes for example, that girls' relatively lower confidence in their math-related skills, as well as their higher levels of math anxiety, are important factors in gender disparities in choosing and persisting in the STEM fields (Aschcraft, 2002; Betz & Hackett, 1983; Dweck & Master, 2008; Eccles et al., 1983).

Within the socio-psychological literature that focuses on gender disparities in STEM fields, there is a relatively new growing body of research on mindset. Mindset, coming from the work on implicit theories of intelligence, is a set of beliefs one holds about his intelligence, both generally, or about domain-specific subjects such as math or science (Dweck, 2008; Dweck & Master, 2008). A small body of research examines gender disparities in mindset and how girls' potentially higher levels of fixed mindset potentially impact patterns of STEM course taking and persistence (Good et al., 2012; Aronson et al., 2002). However, the mindset literature does not engage with the larger existing bodies of research on math confidence and math anxiety, which also find that lower levels of confidence or higher levels of math anxiety are explanations as to why females are less likely to enter into some STEM fields (Betz &Hackett, 1983; Meece et al., 1990). Since there are logical similarities between the more recent research on mindset and the larger and more well-established literatures on math confidence and math anxiety, this study will investigate the possible connections between these different beliefs and how gender differences vary across them.

This study will use data from the National Mindset Study, a new study examining mindset using a large sample of ninth graders across the United States. This study will contribute to the literature by examining whether and how students' mindset differs from their math confidence and math anxiety; in doing so it examines whether adolescents' endorsement of a general fixed mindset regarding intelligence diverge from their endorsement of a fixed mindset regarding the domain of math in particular. After examining the relationship between general mindset and math mindset, as well as the relationship between mindset, math confidence, and math anxiety, this study will then turn to examine gender difference across these different beliefs. Specifically, this study will examine if gender differences are consistent across these beliefs or whether differences are greater for some beliefs compared to others. To consider these gender differences, I will investigate gender differences at the bivariate level as well as net of social and academic backgrounds so that differences between girls and boys with similar characteristics can be detected.

Background

Math Confidence

There is a large research literature documenting how confidence in ability in different domains drives academic outcomes, including achievement and academic performance, course-taking, choice of college major and choice of occupation (Bandura et al., 2001; Betz & Hackett, 1983; Correll, 2001; Eccles & Wang, 2015; Hackett, 1985;

Hackett & Betz, 1989; Multon, Brown & Lent, 1991), as well as persistence in the STEM fields (Cech, Rubineau, Silbey, & Seron, 2011; Lent, Brown & Larkin, 1984; Multon, Brown & Lent, 1991). Regarding gender disparities, the empirical literature finds that males are more confident in STEM fields, particularly in math, compared to females (Correll, 2001; Betz &Hackett, 1983; Eccles, Wigfield, Harold & Blumefeld, 1993; Guo, Parker, Marsh & Mornin, 2015; Wigfield, Eccles, Mac Iver, Reuman & Midgley, 1991). This disparity has consequences for outcomes such as entering into the STEM Fields. The Eccles' Expectancy Value Theory (Eccles et al., 1983) outlines how girls are less confident in their abilities due to their previous socialization experiences (Eccles, 2011). Societal gender roles and cultural gender stereotypes establish norms of what is acceptable for girls (and for boys) Specifically, cultural gender stereotypes dictate that STEM fields are masculine and are not well-suited for girls to enter into these fields (Farland-Smith, 2009; Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005). These outside messages shape girls' confidence, lowering their perceptions of their ability, which then contributes to discouraging them from entering into some STEM fields.

Math Anxiety

Inversely related to math confidence (Akin & Kurbanoglu, 2011; Bourquin, 1999; Jameson, 2013; Pajares & Graham, 1999), math anxiety is an emotional response of discomfort, fear, or tension to working on math or the possibility of working on it (Ashcraft, 2002). Like the math confidence literature, the smaller math anxiety literature suggests that math anxiety predicts math course-taking, math achievement, and persistence (Aschcraft, 2002; Eccles, 2011; Wigfield & Meece, 1988). Further the literature on math anxiety finds a similar pattern where females have higher levels of math anxiety compared to males (Campbell & Evans, 1997; Goetz et al., 2013; Gunderson et al., 2013; Hill et al., 2016; Meece, Wigfield & Eccles, 1990; Wigfield & Meece, 1988; Woodward, 2004). The newer stereotype threat literature offers an explanation for these disparities. This theory recognizes the prevalence of widely known stereotypes, such as those that describe math as a male domain or assume that boys always excel at mathematics (Keller, 2002; Steele & Aronson, 1995), and also acknowledges the importance of a person's immediate environment. In a situation where the stereotype is relevant, a member of the stereotyped group (even if she does not believe the stereotype) feels worried she would be judged based on the stereotype or feels threatened that she will fulfill the stereotype, especially if her performance is low. Typically the person will become anxious or nervous in the performance situation and will perform worse than her ability (Spencer et al., 1999).

Mindset

General Mindset vs. STEM Mindset. While researchers have been studying math confidence and anxiety and their consequence for more than fifty years, the research on mindset is much newer. Mindset, or the beliefs one has about the malleability of intelligence, has been measured in empirical studies with a STEM focus in two ways. Specifically, some studies use a general measure of mindset, focusing on general beliefs about intelligence (Stump, Husman, & Corby, 2014); in contrast, others use a domain specific measure of mindset, such as focusing on beliefs about intelligence in the specific subject of math or science (Chen, 2012; Heyman et al., 2002; Rattan et al., 2012). While some prior research has suggested that it may be important to consider domain-specific mindsets, (Schunk, 1991; Vogler & Bakken, 2007) to date there is only one empirical study (Burkely et al., 2010) that considers both a general measure of mindset in addition to a math specific one. The authors concluded that rather than general mindset measures, domain-specific mindset measures are likely more suitable when studying specific domains; thus this chapter will build on this limited literature and consider the extent to which students' general mindsets are similar or different than their math-specific ones.

The relationship between confidence, math anxiety and mindset

Even though the relatively new research literature on growth and fixed mindset predicts similar outcomes as the large existing literatures on math confidence and math anxiety, there are very few studies that consider the possible connections between these different beliefs. Further, the limited literature that does exist offers little consensus about the relationship between mindset compared to confidence and math anxiety. For example, Bandura (1997) mentions that "viewing ability as an inherent capacity lowers perceived self efficacy, retards skill development, and diminishes interest in the activity" (p. 119). This suggests that mindset may influence confidence, which then predicts, for example, academic outcomes. Some limited evidence from experimental and empirical studies alludes to this possible association between mindset and confidence, where individuals holding a growth mindset are more confident in their abilities, whereas individuals with a fixed mindset are less confident (Burnette et al., 2013; Martocchio, 1994; Tabernero & Wood, 1999;Wood & Bandura, 1989).

However, the literature is far from conclusive, and logically, it is also possible that mindset and confidence are independent of each other (Dweck & Legget, 1988; Cury, Elliot, Da Fonseca & Moller, 2006; Hong et al., 1999) and work together (but separately) to predict academic outcomes (Kornilova, Kornilov, & Chumakova, 2009). For example, a study by Braten and Olaussen (1998) examining the strategy use of 176 pre-service teachers in Norway found that mindset was predictive independent of individuals' confidence. However, studies that do examine both mindset and confidence utilize small samples that may be specific to a particular country (Norway, Russia) or group of students (business graduate students), and thus may not be representative of a larger population. Further, none of the samples examined the relationship between confidence and mindset among high school students. Finally, the relationship between math anxiety and mindset is not at all clear, as no existing research has examined the association between the two.

Mindset and Gender

Returning to the issue of gender disparities, in comparison to the relatively large bodies of research on math confidence and math anxiety, the literature on gender disparities in mindset is very small and not specifically focused on examining disparities in STEM fields. As outlined in Dweck's theory of mindset, girls may be more susceptible to a fixed mindset due to general social stereotypes regarding their presumed lower STEM ability (Dweck, 2008). Specifically, cultural stereotypes convey the notion that math requires innate intelligence, implying ability is fixed, and at the same time also convey the message girls are not good at math, making girls potentially more likely to endorse fixed mindsets (Good, Rattan, & Dweck, 2012). Yet at the same time, it is also possible that boys may be equally or more likely than girls to endorse a fixed mindset as cultural stereotypes dictate that boys have a natural ability in math. In other words, the "fixed" part of mindset favors them, which gives them a logical reason to endorse it.

The empirical studies examining gender differences in general (rather than subject-specific) mindset reveal mixed findings (Hwang, Reyes, & Eccles, 2016). Some of the mindset literature suggests girls may lean toward a more fixed mindset compared to boys (Dweck, 2007; Todor, 2014). For example, in a study of 1,101 Norwegian eighth graders, Diseth, Meland, and Breidablik (2014) found that 8th grade girls had lower levels of growth mindset compared to the boys. On the other hand, Ablard and Mills (1996) examined a sample of slightly more than one hundred students in the 3rd to 11th grades taking courses as part of the Center for Talented Youth at John Hopkins; they found no gender differences in students' endorsement of mindset. Additionally, in a study of approximately 600 adults in Norway, Spinath, Spinath, Reimann, and Angleitner (2003) found that women endorsed a growth mindset about intelligence.

Perhaps the conflicting results regarding gender disparities found in this limited existing literature are due to the specific nature of the individuals being studied. Some samples, such as found in Ablard and Mills (1996) study, are from small and highly select groups that may have different characteristics compared to a national sample, and may also diverge from patterns that would be found among adolescents. Further, some of the other studies, such as Spinath et al. (2003) and Diseth et al. (2014), use samples from different countries than the United States, which might have different cultural norms and mindsets toward intelligence.

Regarding subject-specific (rather than general) mindset, the limited empirical research on gender differences is also mixed. Some evidence suggests that girls are more likely than boys to endorse a fixed mindset (Dweck, 2007; Heyman et al., 2002). For example, Chen and Pajares (2010) find that compared to girls, middle school boys endorse a more growth mindset in science, when controlling for prior achievement. Heyman and colleagues (2002) found that among a sample of freshman undergraduate engineering students, 72% of the females endorsed a fixed mindset about their engineering aptitude, while only 46% of the males held the same view. Conversely, more recent studies that are larger in scope suggest that there may be not gender differences in subject specific mindset (Chen, 2012; Hwang et al., 2016). For example, a national sample of approximately 10,850 tenth grade high school students from the Educational Longitudinal Study: 2002 found females and males do not differ in their endorsement of a fixed math mindset (Hwang et al., 2016). In sum, the limited empirical evidence to date has revealed has mixed findings regarding the relationship between gender and mindset (Heyman et al., 2002; Hwang, Reyes, & Eccles, 2016). Therefore, this study will contribute to the existing literature by conducting a large-scale study of general and math-specific mindset among a national sample of high school students in the U.S, and specifically examine the scope of gender disparities present in each.

This study

Stepping back, few existing studies within the relatively new research literature on mindset have examined its relationship to well-established social-psychological factors such as math confidence and math anxiety, or further examined the distinction between a general and a domain-specific math mindset. Additionally, the empirical findings regarding gender differences in mindset have not established a clear consensus, perhaps due to the fact that many of these studies have limited samples; thus we do not know whether gender patterns documented elsewhere (girls' relatively lower levels of math confidence and relatively higher levels of math anxiety compared to boys) are mirrored by gender patterns in endorsement of a fixed mindset (in math or in general). Finally, the research on the intersection of gender and race/ethnicity is also lacking.

Therefore, this study will address the gaps in the literature by examining the following research questions. First what is the relationship between math confidence, math anxiety, and mindset among a national sample of adolescents? Specifically, this study seeks to establish if general and domain-specific math mindset are in fact distinct from one another, as well as examine the relationship between mindset and the more typically-studied factors of math confidence and math anxiety. Secondly, how does gender predict each of these beliefs? Is there evidence that disparities are similar across these different beliefs, or do the patterns for mindset diverge from the more well-known gender disparities in math confidence and math anxiety?

Data

The data used for this study comes from the National Mindset Study. The National Mindset Study is the first large-scale longitudinal national study of mindset, with a special focus on math mindset and the math classroom. This data is a large, nationally representative sample consisting of approximately 16,000 ninth grade students from seventy-six United States public high schools in 28 different states. Baseline measures (time 1) were collected at the beginning of the school year (in most cases) and a follow up survey (time 2) was administered approximately one month later. The data used for this study comes from the baselines measures of approximately 14,800 students from 75 different schools. Fifty percent of the students were female and 45.45% of the students in the sample identify as white, 11.10% as Black, 16.23% as Hispanic, 3.86% as Asian, and 23.36% identify as multi-racial/ethnic or other.

Plan of Analyses

To examine the relationship between mindset (general and subject specific), math confidence, and math anxiety, I will first use exploratory factor analysis (along with descriptive statistics) to assess whether there is evidence that these beliefs represent distinct factors, retaining factors with eigenvalues greater than 1. Based on the results, I will then make separate scales and calculate the alpha reliability, which captures the internal consistency of the items, or how closely the items are related as a group.

Next, I will use a school fixed effects regression models to examine the relationship between gender and student beliefs. These models take into account variation across schools, so that individual (student) characteristics can be examined net of school variation. First, a bivariate baseline model predicting students' beliefs with only gender in the model will be examined. Next multivariate models will be examined. These models include controls such as race/ethnicity, mother's education, grades, and level of math course (each described below) to determine if gender disparities remain, net of these student characteristics that are also likely associated with the outcome. Last, models including interactions between race/ethnicity and gender will be examined to see whether gender differences in students' beliefs may vary according to students' background.

Dependent variables

Students' fixed mindset was measured by asking students to indicate their level of agreement with the following three statements from a scale of 1 (strongly disagree) to 6 (strongly agree): "You have a certain amount of intelligence and you really can't do much to change it."; "Your intelligence is something about you that you can't change very much."; and "Being a math person or not is something that you really can't change." The first two items were taken from Dweck (1999) and the last item regarding math was taken from Silva and White's (2013) work.

Math confidence was measured by the item from Hulleman and Harackiewicz's (2009) work: "Thinking about the skills and difficulty of your classes, how well do you think you'll do in math in high school?" Response categories were on a Likert scale ranging from a low score of (1) extremely poorly to (7) extremely well.

The last item measures math anxiety and is drawn from Ramirez and Beilock (2011): "In general, how much does the subject of math in (high) school make you feel nervous, worried or full of anxiety?" Response categories are on a 5-point scale ranging from (1) not at all to (5) an extreme amount. Students who were missing on any of these five survey items were removed from the analysis using listwise deletion.

Independent Variables and Controls

Female is the independent variable coded 0 for male and 1 for female. Control variables include student's race/ethnicity, student's self-reported grades, mother's education, and current math course. Race/ethnicity is a categorical variable that distinguishes between white (the reference group), Black, Hispanic, and Asian students, as well as those who identify as multi-racial/ethnic or in another racial/ethnic category. Students were grouped into the multi-racial/ethnic and other category if they checked two or more race/ethnicities or were part of a racial/ethnic group that compromised less than 2% of the sample.[1] Students who were missing on gender and race/ethnicity were removed from the sample using listwise deletion.

Mother's education was measured on an 8 point scale ranging from did not finish high school to doctorate. Student responses marked as "do not know" on the mother education item were imputed using mean substitution as well as students who were missing on the item. Math coursework was divided into 3 categories, which include low (pre-algebra or below), algebra, and advanced math (advanced, honors, pre-AP algebra,

[1] All groups in the multi-racial/ethnic category were very small. The 5 largest groups were comprised of students who identified as Black/White (1.25%); Native American/ White (1.56%); Hispanic/White (1.66%); other /White (1.76%), and Middle Eastern/White (3.04%). All other students, who marked two race/ethnic categories, not including the ones mentioned above, comprised 7.22% of the sample. Also, 3.44% of students marked they were three or more race/ethnicities.

geometry & above geometry). Students who were missing on math coursework were replaced with the mode (algebra). Self-reported grades were on a five point scale ranging from (1) mostly F's to (5) mostly A's. Mean substitution was used to impute students who were missing grades. Dummy variables were created to indicate whether students' scores where mean or mode imputed.

Results

Question 1: What is the relationship between math confidence, math anxiety, math mindset, and general mindset?

Results of factor analysis indicate that there are two factors: the three fixed mindset items load onto one factor and math confidence and math anxiety load onto another factor. While the fixed mindset items load onto one factor, fixed math mindset loads more weakly (.669) compared to the other fixed mindset items (.819 and .811) on that factor. Also, both the math confidence and math anxiety items load onto the second factor (.711 and .768 respectively). Rotating the matrix yields similar results.

To examine the internal consistency between these items, the alpha reliability was determined. The three fixed mindset items have an alpha of .7272, but without the fixed math mindset item, the alpha is .8041, indicating that the fixed math mindset item weakens the internal consistency of the mindset items, or how closely the items are related as a group. Further, the means of the individual mindset variable are different. The two fixed general mindset items, "You have a certain amount of intelligence and you really can't do much to change it" and "Your intelligence is something about you that you can't very much" have means of 2.67 and 2.74 respectively (see Table 1.1), indicating that students are more likely to disagree that intelligence cannot be changed. However, the fixed math mindset item has a mean of 3.73, so students are more likely to agree that math intelligence cannot be changed. Additionally, the correlations between the two general fixed mindset items and the fixed math mindset item are weak (0.3749 and 0.3697. Therefore, a fixed general mindset variable was created from the two general questions about intelligence, and the question about math mindset remains as a separate indicator. Finally, the math confidence item and the math anxiety item have a low alpha reliability of .5723, indicating that these two items poorly measure some underlying factor and should not be used together. Therefore, math confidence and math anxiety will be kept as separate measures.

As seen in the correlation matrix (Table 1.2), there are very weak correlations between math anxiety, math confidence, math mindset, and the general mindset variable. General mindset is also very weakly correlated with math anxiety (.0764) and math confidence (-.1407). In summary, fixed general mindset, fixed math mindset, math confidence, and math anxiety appear to be distinct beliefs held by 9th grade students that are weakly related with one another.

Question 2: To what extent are there gender gaps across these different beliefs?

Descriptive Analysis. Exploratory factor analysis and alpha reliabilities were conducted by gender and the results were similar as above. Table 1.3 shows the means and standard deviations (in parentheses) for each dependent variable along with the controls, shown first for the entire sample and then broken down by gender. The table also shows the effect size, which is the magnitude of the gender difference for each variable as a standard deviation. There is a significant gender difference in the each of the dependent variables. For the general mindset and math mindset variables, girls endorse a more fixed mindset compared to boys. The largest gender disparity occurs in fixed math mindset and math anxiety. Girls endorse a fixed math mindset by only slightly more than .10 of a standard deviation compared to boys, but are about .4 of a standard deviation higher than boys for math anxiety. Tables 1.4 and 1.5 show the correlations between the variables for males and females, which are very similar.

Multivariate Analysis. In table 1.6, school fixed effects models were used to examine the association between gender and the dependent variables of general mindset, math mindset, math confidence, and math anxiety. Since the scales used for dependent variables were different, they were standardized so that the coefficients could be compared across all models and easily interpreted in standard deviation units.

Fixed General Mindset. Model 1 shows the baseline model of the effect of gender on fixed general mindset. The female coefficient is positive but not significant, signifying there are no statistically significant gender differences for fixed general mindset. When the controls are added into the full model (model 2), the gender coefficient increases and becomes statistically significant, indicating that net of certain factors, females do endorse significantly higher levels of fixed mindset compared to males. Post estimation tests comparing the coefficient for female across these two models indicate that they are indeed statistically different. Further exploratory analyses revealed that it was the addition of self-reported grades that resulted in the change in the female coefficient from the baseline mode, as grades negatively predict the outcome, and girls have higher grades than boys. Thus, among females and males with the same grades, females endorse higher levels of fixed general mindset compared to boys.

Further, in the full model 2, higher levels of parental education, higher grades, and advanced math coursework all significantly predict lower levels of fixed mindset, net of all other variables in the model. Also, Black, Hispanic, and multi-racial/ethnic and other students have positive and significant coefficients compared to whites, net of all other variables, indicating these students endorse higher levels of fixed general mindset compared to whites.

Fixed Math Mindset. The dependent variable in model 3 and model 4 is the students' endorsement of a fixed math mindset. As seen in model 3, the female coefficient is positive and significant, indicating females endorse higher levels of fixed math mindset compared to boys. The female coefficient is still positive and significant after the controls are added into model 4. Post-estimation tests indicate that that the baseline female coefficient and the female coefficient from the full model are statistically different; and as with the model for general mindset, exploratory analyses reveals that it is again the addition of grades to the model that increases the gender gap in the outcome. Additionally in model 4, Black students endorse higher levels of fixed math mindset compared to white students, controlling for all other factors. Higher grades and being in an advanced math class (rather than algebra) is associated with significantly lower levels of fixed math mindset, while being in a low level math class (rather than algebra) is associated with significantly higher levels of fixed math mindset.

Math Confidence. Models 5 and 6 display the models predicting students' math confidence. In the baseline model (model 5), the female coefficient is negative and significant, indicating that females have lower math confidence than boys. In the full model (model 6), the female coefficient is negative and significant, net of all controls. Once again post estimation testing finds that the female coefficients from the baseline and full model are statistically different, due to the inclusion of grades. This indicates that females endorse lower levels of math confidence compared to boys at similar levels of self-reported grades. Black and Asian students have significantly higher math confidence compared to whites, controlling for all other variables. Higher levels of parental education predict higher math confidence holding all other variables constant. Further, students with higher grades have higher levels of confidence, and compared to student in algebra, students in advanced classes have higher levels of math confidence, while students in lower level math classes report lower levels of math confidence.

Math Anxiety. Finally, models 7 and 8 display the results of analyses where math anxiety is the dependent variable. In model 7, the female coefficient is positive and significant, indicating that females have significantly higher math anxiety than males. In model 8, the controls are added to the model. In the full model, the female coefficient increases in magnitude and is still statistically significant. As with previous models for the other outcomes, the female coefficient in the baseline and full models are statistically different, due to the inclusion of grades. Once again, after taking into account girls' higher academic performance, the gender gap in beliefs increases. Regarding other variables in the model, higher grades are associated with lower levels of math anxiety and students in advanced math classes have higher levels of anxiety compared to students in algebra.

Summarizing Gender Disparities. To determine whether gender gaps were more pronounced for some beliefs, such as math mindset, compared to others, I performed a series of post-hoc comparisons of the female coefficients in different models using the suest command in Stata. First, I compared the female coefficient across the baseline models to assess where the largest (and smallest) gaps were before accounting for control variables. This confirmed that in the baseline model, the gender gap in general mindset was the smallest and the disparity for math anxiety was the largest. In the baseline models, both the disparity in math mindset and math confidence were statistically equivalent in magnitude. After taking the controls into account, I examined the gender disparity for the full models. Once again, the smallest gender disparity was for general mindset and the largest was for math anxiety. However, in the full models, the magnitude of gender disparity in math confidence was statistically bigger than math mindset.

Further, since the inclusion of grades led to an increase in gender disparities across all of the dependent variables, I also compared the impact of grades across the different dependent variables. Post-estimation tests revealed that the grades coefficient for math confidence was statistically greater in magnitude than for the other 3 dependent variables (general fixed mindset, fixed math mindset, and math anxiety). This indicates that a student's academic performance in schools is more highly predictive of their math confidence than the other student beliefs considered, including their math mindset.

Supplemental Analysis. To further assess if gender gaps varied in relation to students' racial/ethnic backgrounds across the four beliefs, interactions between gender and race/ethnicity were added to the models (see Table A.1 in the Appendix starting on page 87) for the supplemental analysis. In the fixed general mindset model, (model 1), the Hispanic female interaction term is positive and significant. In model 2 for fixed math mindset, there are no significant gender-race interactions. For math confidence (model 3), the black female coefficient is negative and significant, controlling for all other variables. In model 4 for math anxiety, the black female coefficient is negative and marginally significant, net of all other variables. To examine the interactions, predicted outcomes for males and females were computed for the four dependent variables, with parental education, grades, and math coursework held at the mean. (Please see the Appendix for the figures for the supplemental analysis.)

For fixed general mindset (see Figure A.1), there is a gender gap across all race/ethnic backgrounds, except for the multi-racial/ethnic and other category, since females in this category do not endorse statistically different beliefs than their male peers. The gender gap is smallest among white students because white females endorse lower levels of fixed general mindset compared to their Black, Hispanic, and Asian female peers. For fixed math mindset (see Figure A.2), there is a gender gap across all race/ethnic backgrounds expect for Asians, since Asian females do not endorse statistically different fixed math mindset compared to their Asian male peers. The gender gap in fixed math mindset is largest for Black students. This is driven by the fact that Black females endorse statistically higher levels of fixed math mindset compared to other females. Now turning our attention to math confidence (see Figure A.3), there are significant gender gaps across all race/ethnic backgrounds. All females have similar levels of math confidence, but the gap in math confidence is biggest among Black students because Black males have higher confidence compared to their female peers. For math anxiety (see Figure A.4), once again there is a gender gap across all race/ethnic backgrounds. This gender gap is similar in size for all race/ethnic groups since females across all race/ethnic groups have similar levels of math anxiety and males across all race/ethnic groups also have similar levels of math anxiety. In sum across all these four beliefs, (with the expectation of multi-racial/ethnic and other students for fixed general mindset and Asians for fixed math mindset) there are gender gaps across all race and ethnic backgrounds.

Conclusion & Discussion

Using a large sample of 9th grade high school students, this empirical study set out to answer two questions. First, what is the relationship between mindset, math confidence, and math anxiety? And secondly, to what extent does gender predict each of these? These research questions were informed by the large body of literature on math confidence and math anxiety as well as the emerging literature on mindset, in addition to literature about inequality in the STEM fields.

The analyses showed that fixed general mindset, fixed math mindset, math confidence, and math anxiety are clearly distinct constructs. In particular, the findings regarding mindset and confidence being independent of each other are consistent with Dweck's (1999) theoretical work and add to the empirical literature (Cury et al., 2006, Hong et al., 1999; Kornilova et al., 2009). Further, this study adds a new contribution to the mindset and math anxiety literature since no previous studies examined the relationship specifically between mindset and math anxiety. Future work on the relation of mindset and math anxiety should be considered, as there is little research on the relationship between the two.

Next the finding that general mindset and math mindset are separate constructs supports the idea suggested in some prior literature (Dweck, 1999; Burkely et al.,2010; Schunk, 1991) regarding the importance of separating mindset into domain specific constructs. By separating the mindset items, a clear picture emerges of students' specific mindsets depending on the particular domain, as a student can endorse a growth mindset in one subject and a fixed mindset in another. Further, when a more general mindset construct is used it may not fully capture students' beliefs as possible domain-specific mindsets may be muted or may not fully measure the person's mindset.

Secondly, this studied examined gender differences in mindsets, math confidence, and math anxiety utilizing a national sample of adolescents. Consistent with prior literature on math confidence and math anxiety (Betz & Hackett, 1983; Correll, 2001; Meece et al., 1988), adolescent girls in this national sample of 9th graders reveal lower math confidence and more math anxiety than boys, even net of a host of controls including academic performance. The results also revealed that there are significant gender differences in both general mindset and math mindset, such that compared to males, females endorse more fixed general and fixed math mindsets. This finding is consistent with cultural stereotypes which convey that math requires innate intelligence along with stereotypes that females are not as innately good at math, likely leading girls to endorse fixed mindsets (Heyman et al., 2002; Diseth et al., 2014).

However, the findings differ from Hwang and colleagues' (2016) work, which did not find a statistical gender difference in endorsement of girls' and boys' fixed math mindset. This may due to the fact that the question used to assess math mindset (being a math person is something you can't really change) may not be comparable to other measures of mindset, such as the mindset item used by Hwang and colleagues (2016) taken from the Educational Longitudinal Survey: 2002 (ELS:2002). The ELS:2002 item asks students about their beliefs regarding innate ability, in contrast to the one in this study which asks about changing who one is. This difference in wording could in fact tap different types of student beliefs. Another explanation of why the results may differ is that the students were surveyed at different points during high school. The National Mindset Study surveyed students within the first few weeks of beginning 9th grade. These students may still not feel comfortable with their environment and expectations of high school and also be less developed in their thinking and beliefs compared to older students. The students surveyed in the Educational Longitudinal Survey: 2002 completed the survey by the spring of their sophomore year. These students are established within the school and are also about two years older than incoming freshmen, and possibly could have different beliefs than freshmen who just started high school. Therefore, more work needs to be done to more firmly establish whether there are pervasive and consistent gender differences in mindset.

Further, while the results did find gender disparities in mindset, it is important to note that the biggest gender gap (.39 standard deviations) was found for math anxiety. Drawing from the stereotype threat literature, the gender gap in math anxiety may be due to the constant performance situation in math class – where everything a girl says or does can be considered a performance situation; thus she feels anxious she will confirm the stereotypes that boys are better at math (Spencer et al., 1999; Steele & Aronson, 1995). Furthermore, across all student beliefs, the analyses revealed that once students' grades were included in the models, gender dipartites significantly increased. This suggests that grades could be considered protective for girls; in other words, if they did not have higher grades than their male peers, the gender gap in math-related beliefs would be even more pronounced.

Finally, it is worth noting that the multivariate results revealed a stronger association between academic performance and students' math confidence than found among the other student beliefs. This suggests that perhaps fixed general mindset, fixed math mindset, and math anxiety are more influenced by cultural beliefs and stereotypes than actual feedback from teachers regarding academic performance. Furthermore, the full models including all control variables accounted for much less variance in students' mindset (both general and specific) and anxiety (about 3-6%) compared to the models for math confidence (where about 20% of the variance is explained). Therefore more research should examine what other factors in students' backgrounds and experiences are associated with these beliefs.

As with any study, this study has limitations. First, there was only one item measuring three of the outcomes: math mindset, math confidence, and math anxiety. Using more than one item would have provided a more reliable measure for each of these psychological constructs. Further, this study uses cross-sectional data and cannot speak to when students acquired their fixed mindsets, math confidence, or math anxiety. This study only examines students starting the 9th grade and their beliefs and gender disparities at that particular time. Additional research should be done to examine how these beliefs change over time- and to see whether and how gender gaps widen or close over high school. In sum, this study contributes new information about the four constructs of general fixed mindset, fixed math mindset, math confidence, and math anxiety, and examines how gender predicts each. By better understanding these beliefs and the gender disparities within them, we can work toward greater gender equity in the STEM fields.

Table 1.1. Item Descriptions: Mindset, Confidence, and Math Anxiety

Item	Question	Scale	Mean
Fixed Mindset 1	You have a certain amount of intelligence and you really can't do much to change it.	(1) Disagree (6) Agree	2.67 (1.38)
Fixed Mindset 2	Your intelligence is something about you that you can't very much.	(1) Disagree (6) Agree	2.74 (1.43)
Fixed Mindset (math)	Being a math person or not is something that you really can't change.	(1) Disagree (6) Agree	3.73 (1.44)
Math Confidence	Thinking about the skills and difficulty of your classes, how well do you think you'll do in math in high school?	(1) extremely poorly (7) extremely well	5.17 (1.18)
Math Anxiety	In general, how much does the subject of math in (high) school make you feel nervous, worried or full of anxiety?	(1) not at all (5) an extreme amount	2.53 (1.15)

n =14,783
Standard deviations in parentheses

Table 1.2. Correlations between Mindset, Confidence, and Math Anxiety

(*n*=14,783)	General Mindset	Math Mindset	Math Confidence	Math Anxiety
General Mindset	1.0000			
Math Mindset	0.4071	1.0000		
Math Confidence	-0.1407	-0.1638	1.0000	
Math Anxiety	0.0764	0.1255	-0.4010	1.0000

Table 1.3. Descriptive Statistics: Means and Standard Deviations

Variable	Mean (*n* =14,783)	Male (*n* =7,499)	Female (*n* =7,284)	Effect Size (Cohen's d)
General mindset	2.70	2.68	2.73*	-.037
	(1.29)	(1.30)	1.27	
Math mindset	3.73	3.65	3.81***	-.113
	(1.44)	1.48	1.40	
Math confidence	5.17	5.21	5.12***	.079
	(1.18)	(1.19)	(1.17)	
Math anxiety	2.53	2.32	2.75***	-.390
	(1.15)	1.09	1.16	
Mother's education	3.70	3.74	3.65**	.056
	(1.63)	(1.62)	(1.65)	
Grades	4.07	3.94	4.21***	-.307
	(0.89)	(0.01)	(0.01)	
Math Course	2.25	2.41	2.26*	-.033
	(0.59)	(0.58)	(0.59)	

***p<.001 ** p<.01 *p<.05 ~ p<.10
Standard deviations are in parentheses

Table 1.4. Correlations between Mindset, Confidence, and Math Anxiety by Gender: Males

(*n* =7,499)	General mindset	Math mindset	Math confidence	Math anxiety
General mindset	1.0000			
Math mindset	0.3974	1.0000		
Math confidence	-0.1417	-0.15431	1.0000	
Math anxiety	0.1052	0.1136	-0.3628	1.0000

Table 1.5. Correlations between Mindset, Confidence, and Math Anxiety by Gender: Females

(*n* =7,284)	General mindset	Math mindset	Math confidence	Math anxiety
General mindset	1.0000			
Math mindset	0.4173	1.0000		
Math confidence	-0.1382	-0.1719	1.0000	
Math anxiety	0.0438	0.1214	-0.4395	1.0000

Table 1.6. Regression Analyses Predicting Fixed General Mindset, Fixed Math Mindset, Math Confidence, and Math Anxiety

VARIABLES	Model 1 Fixed General Mindset	Model 2 Fixed General Mindset	Model 3 Fixed Math Mindset	Model 4 Fixed Math Mindset	Model 5 Math Confidence	Model 6 Math confidence	Model 7 Math Anxiety	Model 8 Math Anxiety
Female	0.0294*	0.0741***	0.101***	0.141***	-0.0834***	-0.209***	0.377***	0.416***
	(0.0149)	(0.0148)	(0.0162)	(0.0163)	(0.0163)	(0.0148)	(0.0161)	(0.0162)
Race/Ethnicity (Reference: White)								
Black		0.109***		0.111***		0.119***		-0.0200
		(0.0285)		(0.0313)		(0.0284)		(0.0311)
Hispanic		0.0960***		-0.00224		0.00820		0.00716
		(0.0246)		(0.0270)		(0.0245)		(0.0269)
Asian		0.0600		-0.0709		0.0987*		-0.0663
		(0.0393)		(0.0431)		(0.0391)		(0.0429)
Multi & Other		0.0554**		0.0153		0.0223		0.0476*
		(0.0195)		(0.0214)		(0.0195)		(0.0213)
Mother's education		-0.0106*		0.00375		0.0201***		0.00424
		(0.00502)		(0.00551)		(0.00500)		(0.00548)
Academic Variables								
Grades		-0.130***		-0.134***		0.474***		-0.157***
		(0.00947)		(0.0104)		(0.00945)		(0.0103)
Math course: (Reference: algebra)								
Below Algebra		0.135***		0.101**		-0.0764**		0.0420
		(0.0293)		(0.0322)		(0.0292)		(0.0320)
Advanced		-0.0973***		-0.0715***		0.160***		0.100***
		(0.0187)		(0.0206)		(0.0187)		(0.0205)
Additional Controls								
Missing for mother's education		0.165***		0.0487*		-0.00266		-0.0822***
		(0.0194)		(0.0214)		(0.0194)		(0.0212)
Missing for grades		0.136		0.220		-0.562***		0.245
		(0.154)		(0.169)		(0.153)		(0.168)
Missing for math course		0.00682		0.00398		-0.0371		0.0859**
		(0.0242)		(0.0266)		(0.0241)		(0.0264)
Constant	-0.0145	0.479***	-0.0498***	0.456***	0.0411***	-1.967***	-0.186***	0.376***
	(0.0104)	(0.0429)	(0.0113)	(0.0471)	(0.0114)	(0.0427)	(0.0112)	(0.0468)
R-squared	0.000	0.039	0.003	0.024	0.002	0.204	0.036	0.054

Observations: 14,783; number of schools: 75; Standard errors in parentheses; ***p<0.001, ** p<0.01, * p<0.05

Chapter 2: Examining High School Math Teachers' Beliefs about Student Learning and their Pedagogical Practices

Introduction

Teacher beliefs have long been a topic of research in the educational literature. Research has focused on teacher beliefs in the form of confidence in the content they teach or activities they perform in the classroom, as well as, their perceptions of their self worth. Teacher beliefs are also comprised of the beliefs teachers hold about their students and schooling in general (Pajares, 1992). Scholars have worked to understand teacher beliefs as teachers' views and perceptions influence their actions and behaviors in the classroom (Calderhead, 1996; Kane, Sandretto, & Heath, 2002; Pajares, 1992).

A recent body of mostly qualitative research has emerged that examines teacher beliefs of students' learning potential and whether and how it is limited due to students' home environment. This research describes what is referred to as deficit thinking, meaning that a students' inability to learn (or not learn) is directly attributed to a deficit in the student's family background (Garcia & Guerra, 2004; Valencia, 2012). Examining whether teachers endorse such deficit beliefs is important, as some studies find evidence suggesting that these beliefs may negatively impact students and classrooms in a variety of ways. For example, endorsing deficit beliefs lowers teachers' expectations of students and also impacts the classroom environment as teachers with these beliefs offer less rigorous work and provide students with less opportunities for collaboration (Garcia & Guerra, 2004; McKenzie & Scheurich, 2004).

While research using the framework of deficit thinking regarding teachers is relatively recent, it is important to note that its foundation lies in an earlier body of work on teacher efficacy, or a teacher's belief about her ability to teach effectively and promote student learning (Tschannen-Moran & Woolfolk Hoy, 2001; Tschannen-Moran, Woolfolk Hoy & Hoy, 1998). Within the vast literature on teacher efficacy, one prominent strand examined teachers' beliefs about teaching to overcome students' home environment (Coladarci, 1992; Tschannen-Moran & Woolfolk Hoy, 2001; Woolfolk & Hoy, 1990). Although contemporary research on teacher efficacy has moved more toward examining specific aspects of teacher's efficacy such as efficacy for classroom management, instructional strategies, or student engagement, the previous quantitative body of research on teacher efficacy called needed attention to the possibility that when teachers believed that negative home environments overshadowed their own efforts in the classroom, they were less likely to promote student autonomy in the classroom and more likely to use bureaucratic type practices and have low enthusiasm for teaching (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990).

This paper builds on the combined insights of the recent research on teachers' deficit thinking with earlier research on teacher efficacy by examining teachers' beliefs about whether students' home environment is the strongest determinant of their learning potential, and the potential consequences of such beliefs for their pedagogical choices in the classroom. Specifically, to the extent that teachers hold deficit beliefs regarding students' ability to learn, they may be unlikely to view students as capable and motivated to engage in active learning. Consequently, teachers endorsing these views may be less likely to use reform based pedagogical practices and focus their attention on reinforcement of basic skills, as they are unlikely to think their students are capable of the higher level thinking needed for reform based practices. Moreover, research finds strong links between reform-based pedagogy and student's conceptual understanding and achievement in math and science (Boaler, 1998; Geier et al., 2008; Hanze & Berger, 2007; Krajcik et al., 1998; Petrosino et al., 2003; Zakaria, Chin, & Daud, 2010); therefore, teachers' deficit beliefs likely have negative implications for students' learning outcomes.

To address these issues, I utilize data from the High School Longitudinal Study: 2009, a national study focusing on math and science outcomes conducted by the National Center for Education Statistics. This dataset includes surveys of approximately 4,200 high school math teachers across the country. This study provides an ideal opportunity to examine the prevalence of deficit beliefs among high school math teachers and to investigate whether such beliefs may be related to the use of reform teaching practices that are known to promote student learning and engagement (Boaler, 1998; Geier et al., 2008; Krajcik et al., 1998; Petrosino et al., 2003).

Background

Prior Research on Teachers' Efficacy to Overcome Obstacles in the Home Environment

In the 1980's and 1990's, researchers studying teacher efficacy typically defined 'general teaching efficacy' as a belief that good teaching can counter any negative influences in students' background, including obstacles in the student's home environment, parental discipline, and student motivation and performance (Tschannen-Moran & Woolfolk-Hoy, 2001). This limited definition of efficacy dominated much of the empirical literature on teacher beliefs, and produced evidence that such beliefs predicted commitment to teaching (Coladarci, 1992), academic success (Soodak & Podell, 1993), types of instructional approaches, and classroom management (Brownell & Pajares, 1999; Gibson & Dembo, 1984; Soodak & Podell, 1994; Woolfolk & Hoy, 1990). Studies suggested that higher levels of general teaching efficacy (or beliefs that teaching can overcome the students' home environment) predict less authoritarian classroom control and the use of more collaboration between the teachers and students (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990). For example, in a study consisting of 104 elementary and 78 secondary pre-service teachers in liberal arts majors, general teaching efficacy was negatively related to bureaucratic orientation, implying the more teachers believed in schooling to overcome obstacles in the students' environment, the less likely teachers had a bureaucratic perspective (Woolfolk & Hoy, 1990). Similarly, a survey of 55 religious middle school language teachers schools found teachers who believed all students can learn, regardless of background, used a more humanistic approach in the classroom and supported student autonomy (Woolfolk, Rosoff & Hoy, 1990). Moreover, teachers who endorsed high levels of general teaching efficacy were more trusting of their students, shared responsibility of problem solving with their students, and had more personal connections with their students, and also had higher levels of clarity and enthusiasm toward teaching and instruction (Allinder, 1994; Summers, David & Hoy, 2017; Woolfolk et al., 1990).

Beginning in the late 1990's and early 2000's, researchers began to question whether measures of 'general teaching efficacy' were in fact valid measure of teachers' efficacy, and called for more specificity in efficacy measures, such as measures that were more domain specific and more centered around teachers' confidence in developing rigorous curriculum or activities (Tschannen –Moran, Hoy & Hoy, 1998). For example, Henson et al. (2001) examined Gibson and Dembo's (1984) teacher efficacy scale and concluded that the general teaching efficacy subscale is problematic due to reliability and validity. Particularly, the question of validity was raised as the general teaching efficacy scale does not actually focus on teachers' confidence but on external factors (home environment) that can influence students' outcomes (Henson et al., 2001; Tschannen-Moran & Hoy, 2001). Further, researchers expressed concern that the measures were not representative of an individual teacher's view of herself, but what the individual teacher believes about the collective teacher profession (Henson et al., 2001; Tschannen-Moran, & Hoy, 2001). Due to these concerns, the literature on teaching efficacy has shifted towards capturing different dimensions of teacher efficacy, including teachers' confidence in using different instructional strategies, deploying effective classroom management, and promoting student engagement.

Qualitative Research on Teachers' Deficit Thinking

At the same time the validity of general teaching efficacy was being questioned, a large body of qualitative literature on deficit thinking began to emerge. This literature parallels the general teaching efficacy literature in that it examines teacher's beliefs of how students' background or home environment is a major obstacle to their learning capacity and success in school (Delpit, 1995; Garcia & Guerra, 2004). Teachers holding deficit views place the blame of student underperformance on factors outside the classroom and school (McKenzie & Scheurich, 2004). Teachers attribute the lack of student success to cultural inadequacies, lack of motivation, poor student behavior, and torn apart families and failed communities, especially for students of low socio-economic status and students of color (Garcia & Guerra, 2004; McKenzie & Scheurich, 2004; Smit, 2012). Further, students' lack of intrinsic motivation in school is blamed on parents not valuing education and students' misbehavior at school is blamed on not being properly taught to behave at home.

Some studies suggest that these deficit beliefs may be detrimental to students learning and achievement as teachers' beliefs motivate practice within the classroom (Guerra & Nelson, 2009; Mckenzie & Scheurich, 2004; Pollack, 2013; Smit, 2012). For example, in a qualitative study of 8 white elementary school teachers working in high minority and low income school, teachers with deficit beliefs had low student expectations, were less likely to challenge students, and taught less rigorous curriculum; at the same time they did not blame themselves for students' underachievement and disregarded students' learning potential (Mckenzie & Scheurich, 2004). It is important to note that deficit beliefs do not necessarily mean that teachers do not care about their students, but by caring they may "shield" the student away from hard material and water down the curriculum (Pollack, 2013). Drawing from their research of 185 elementary and high school teachers, principals, and administrators, Garcia and Guerra (2004) found that even when teachers did provide instruction, their negative beliefs about students' learning potentials and families seem to have lowered their expectations for student performance as well as their response to students' "underachievements" (p. 161). When asked why students were not doing as well, only a few teachers identified the curriculum, pedagogical practices, or teacher preparation as reasons why students do not succeed.

The Link between Teachers' Beliefs and Reform Pedagogical Practices

Both the earlier quantitative literature on general teacher efficacy and the more recent literature on teachers' deficit thinking provide compelling evidence that teachers' beliefs about the importance of the home environment have clear connections to their actions in the classroom. Building on these insights, this study expands the line of research in this area by examining whether deficit views may have implications for teachers' use of reform pedagogy. Specifically, reform teaching practices can be characterized as encompassing ideas from constructivist teaching practices, which encourages students to create their own knowledge based on prior experiences and engaging with new ideas (Resnick, 1989). Other characteristics may include teacher facilitated learning and conversations with shared understanding of material and concepts, student centered classrooms, tasks that help students build understanding or meaning, exploring or experimentation, and developing students' understanding of what they do and do not understand (Richardson, 2003). Further, reform practices can take many forms including project based instruction, hands on learning, experimentation, solving an authentic question, and whole class discussions (Barron et al., 1998; Krajcik, 1998).

As we see from the literature on teacher beliefs about students' learning, some research finds an association between teacher endorsement of deficit beliefs and teacher practices, including teacher-student interaction, humanistic approaches for control, student autonomy in the classroom, and predictions of student success in the classroom, all of which are consistent with the characteristics of reform pedagogical practices (Soodak & Podell, 1993, Woolfolk, Rosoff & Hoy, 1990). Therefore, it would be logical to extend these practices to the use of reform pedagogies within the math classroom, as high school math teachers endorsing deficit views of students may be more likely to see their students as limited and not capable of achieving high standards, use practices such as having students learn basic computational skills, math facts, and memorizing formulas, and emphasize behavior and discipline to make up for the "deficit" the student has, instead of having the students construct their own knowledge and understanding of the material through applications and critical thinking. When endorsing deficit view of students, reform practices might receive less emphasis in favor of procedural types of exercises as teachers are more likely to think that students would not be able to do more critical thinking type applications. Therefore, it is critical to understand the association between high school math teacher beliefs and the use of reform pedagogical practices, as the literature on reform practices suggest reform practices increase student engagement, increase student understanding and student achievement, and increase student interest and confidence in the material.

Importantly, while previous research on this topic is strongly suggestive of a link between deficit beliefs and pedagogical choices, it is quite limited in scope. Most of the studies, especially from the qualitative deficit thinking literature, utilize very small samples or use samples of pre-service teachers or elementary school teachers whose beliefs and practices likely diverge from those of practicing teachers or from high school teachers, respectively. The samples used in the studies are very specialized, for example, including teachers from only religious schools or special education teachers (Woolfolk et al., 1990; Soodak & Pollack, 1994). Therefore, this study will make a new contribution to the literature by examining the relationship between teachers' endorsement of deficit views of student learning and their pedagogical practices by using a large sample of high school math teachers drawn from schools across the United States. Doing so provides a more generalizable picture of the connections between deficit beliefs and the use of reform pedagogy among teachers in high schools nationwide.

Data

Participants

The data used for this study comes from the High School Longitudinal Study of 2009. The High School Longitudinal Study is a nationally representative sample of approximately 23,000 ninth graders coming from 944 schools across the United States. The High School Longitudinal Study surveys students' attitudes and beliefs about mathematics as well as their algebraic reasoning, and problems solving skills in both 9^{th} and 11^{th} grade to study students' transition into postsecondary paths, with an emphasis on STEM outcomes. Baseline measures for students were collected at the beginning of the 9^{th} grade and follow up surveys were administered in 11^{th} grade, and transcripts were collected in 12^{th} grade. Further, students' math and science teachers, along with parents and schools administrators were surveyed as part of the baseline measures to provide contextual information. The data used for this study comes from the base year math teacher surveys.

Since the unit of analysis in the High School Longitudinal Study: 2009 is students, a matching procedure was used to identify teachers within the data set. The matching procedure[2] yielded approximately 4200 math teachers that were surveyed. Our sample was limited to teachers who answered the reform practices items on the survey along with gender and minority status, years teaching, STEM major. Math teachers missing on the independent variables of deficit beliefs, teachers' expectations at their school and perceptions of the math professional learning community in their school were imputed, leaving a final sample of 3,503 high school math teachers. This is a much larger sample than used in many of the empirical studies reviewed and importantly, it is a

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[2] In order to obtain a sample of only teachers a matching procedure was used on the base year student dataset (using the restricted file). Students who did not take a math class in fall 2009 or teachers who did not respond to the survey (variable X1TMQSTAT) were dropped. All other data was dropped leaving only the math teacher questions and composites along with school id from the whole file (total of 154 variables). The teacher data is compromised of variables that stay the same and other variables that are course dependent. First, teacher identification was made using the egen- grouping function in STATA. The grouping function creates a numeric variable (id) based on the groups formed within the variable list. For example, if multiple observations in the grouping list have the same value for each of the variables, then each record gets the same id. On the other hand, if one variable in the grouping list has a different value, this observation gets assigned a different id. One hundred thirty five variables were used in the grouping list including two verbatim responses, but the course dependent variable were not included in the grouping list, in order not to identify the same teacher more than once. Once the egen-grouping function was applied, all duplicate observations were dropped. The remaining data identifies teachers, but some teachers can have multiple observations if they taught more than one math course in the fall of 2009. Since a teacher can teach more than one math class, the information was collapsed into one observation.

survey of practicing high school math teachers in the United States.

Dependent Variable

The dependent variable captures math teachers' use of reform or constructivist approach to math teaching. This scale includes ten items, such as teachers' emphasis on "teaching students how mathematical ideas connect with one another", "increasing students' interest in math, developing students problem solving", "teaching students to explain ideas in math effectively"; and "teaching students how to apply mathematics in business and industry". This scale was the average of the items scores on a 1 (no emphasis) to 4 (heavy emphasis) scale. The alpha reliability for scale is .84. (Please see the Appendix for all the items.)

Independent Variable and Controls

The key independent variable is a scale measuring teachers' endorsement of a deficit view of student learning. It is comprised of five items, including: "the amount a student can learn is primarily related to family background"; "when it comes down to it, you really cannot do much because most of the students' motivation and performance depends on their home environment"; "if a student is not disciplined at home, they are not likely to accept any discipline at school"; "if parents would do more for their children, you could do more for your students"; and "you are very limited in what you can achieve because a student's home environment is a large influence on their achievement". Response categories ranged from 1 (strongly agree) to 4 (strongly disagree) and response were reverse recoded so that higher scores indicate more agreement with the deficit view of student learning. The alpha reliability for this scale is .75.

Several controls capture teachers' background, including gender, minority status, STEM undergraduate field of study, and years of teaching experience. Female, minority, and STEM undergraduate field of study are dichotomous variables, and years of math teaching experience was recoded into 3 categories of approximately similar size, consisting of 1-5 years, 6-15 years, and 16 or more years. An additional variable captures the level of the math course the math teachers teach with higher values corresponding to more advanced coursework on a 3 point scale: 1 (below algebra), 2 (algebra), to 3 scale (above algebra).

Further, two standardized continuous composite variables created by NCES will be used as controls for the school environment. They include the scale of math teachers' perceptions of math teachers' expectations at their school and perceptions of the math professional learning community in their school. These two variables account for the type of school environment the teacher works at and gives a better sense of how the school culture and math community climate play into shaping the use of reform pedagogy. The scale of math teacher's perception of math professional learning community is comprised of 12 items on a 1 (strongly agree) to 4 (strongly disagree) including "math teachers in this department share ideas on teaching", math teacher in this department discuss lesson that were not successful"; "math teachers in this department discuss beliefs about teaching / learning"; and "math teacher in this department share research on effective teaching methods". (Please see the Appendix for the complete list of items.) The scale of perceptions of math teachers' expectations at their school is compromised of eight items on a 1(strongly agree) to 4 (strongly disagree) including, "math teachers in this school expect very little from students”;   “math teachers in the school work hard to make sure all students learn”; “math teachers in this school care only about smart students”; “math teachers in this school have given up on some students”; math teachers in this school make goals clear to students”, “math teachers in this school believe all students can do well”; “math teachers in the school set high standards for students' learning”; and “math teachers in this school set high standards for teaching”. Higher values for both scales indicate higher perceptions of expectations and higher perceptions of greater professional learning community, respectively.

Results

Descriptive Results

Table 2.1 displays the means and standard deviations for the dependent variable as well as descriptive statistics for the independent variable and controls, Table 2.2 examines teacher’s endorsement of deficit thinking based on their characteristics, and Table 2.3 displays the correlations between the independent variable and school characteristics. Beginning with the dependent measure of reform pedagogy, the average among math teachers in the analytic sample is 3.30 with a standard deviation of .39, indicating that teachers on average place a higher emphasis on reform type practices in the their math classrooms. Moving to the independent variable, deficit thinking, the average math teacher has a mean of 2.43, and with a standard deviation of .50. This indicates that on average high school math teachers are slightly more likely to agree with a deficit view of thinking.

The high school math teachers in this sample are majority female, majority white, and approximately 40% of teachers are beginning teachers with one to five years of experience. Further, 40% of high school math teachers in this sample majored in a STEM degree. Moving to Table 2.2, we see that male teachers are significantly more likely than female teachers to endorse deficit views (male mean =2.53, female mean =2. 36). Also, teachers who have taught math less than 16 years endorse significantly higher deficit views than teachers who have taught more than 16 years. However, there is no significant difference in endorsement of deficit thinking between white and minority teachers, type of undergraduate degree (STEM or non-STEM), and level of math class the taught.

In Table 2.3, we see the correlations between the deficit variable and the school characteristics. Deficit thinking and math teachers' perception of supportive professional learning communities in their school is negatively correlated; deficit thinking is also negatively correlated with high teachers' expectations at their school. However, both correlations are quite small (-.0568 and -.1546, respectively); this indicates a very weak association between the deficit views teachers endorse and their school cultures or type of school they teach in. The association between the math teachers' perceptions of a math professional learning community and perceptions of math teachers' expectations at their school is .4762 indicating a positive and moderate relationship between the two school characteristics.

Multivariate Results

To examine the relationship between math teachers' deficit thinking and reform pedagogical practices, school fixed effects models were used[3]. Analyses begin with baseline models, which only include the independent variable capturing teachers' beliefs. Next multivariate models will be examined. The multivariate models include the control variables described above to determine whether deficit beliefs about student learning predict pedagogical practices net of other factors.

Beginning with Model 1, the results in Table 2.4 show that teachers' endorsement of a deficit view of student learning is negatively and significantly related to their use of reform- based pedagogy. The coefficient is slightly reduced but still significant with the inclusion of the control variables in Model 2. Among the control variables, we see that years of experience is also significant, with beginning teachers less likely to use reform pedagogy. Further, teaching a more advanced math course is predictive of using reform pedagogy as well as having a STEM major for an undergraduate degree since the coefficients are positive and significant. Further, the school climate controls of teachers' expectations and learning communities are positive and significant, indicating higher expectations and more use of learning communities is predictive of using reform pedagogy. [4]

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[3] Correlations between the deficit variable and the school characteristics of percent free lunch and percentage of students repeating 9th grade were weakly associated (.19 and .10, respectively), indicating that teachers in higher poverty schools or schools with more students repeating the 9th grade were only slightly more likely to endorse a deficit mindset.

[4] As a robustness check, since all our analysis are performed with the unit of analysis as the teacher, all analysis were performed again with (teachers of) students as the unit of analysis. The appropriate survey weight for the math teachers (M1MTHTACH) was used to account for the population, along with Taylor expansion (linearization) to account for appropriately adjusting

To examine the possibility that the association of deficit thinking with teachers' pedagogical choices might differ based on the level of math course they were teaching, I also ran models that interacted the deficit variable with the math course-taking variables. None of the interaction were significant, indicating that regardless of the level of course they were teaching, teachers' endorsement of deficit thinking had a similar relationship to their use of reform pedagogy.

Discussion and Conclusion

Using a large sample of high math teachers, this empirical study sought to address whether teacher beliefs predict their pedagogical practices. Specifically, whether teachers' endorsement of a deficit view of student learning, such that they believe that the home environment is the main determinant of students' ability to learn math, is related to reform teaching practices. These research questions were informed by the limited literature on general teaching efficacy and the large qualitative literature on deficit thinking.

The results of quantitative analyses reveal that high school math teachers' endorsement of deficit views of student learning predicts less of an emphasis on reform-based pedagogical practices. These results are robust to the inclusion of an array of control variables, including measures of teachers' background, their perceptions of other aspects of their teaching environment, and the level of math course that they teach. Thus,

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standard errors when performing robustness checks. Similar results were obtained when comparing the unit of analysis as teacher compared to students.

strong empirical evidence is provided that high school math teachers' deficit beliefs are related to their choice of reform pedagogy in the math classroom. These results of the analyses offer a new contribution to the deficit thinking and math education literature, as this relationship was found for large sample of high school math teachers across the United States. The previous empirical literature may not be generalizable to high school math since the samples were small, coming predominately from pre-service and elementary school teachers, and were not specific to the math domain.

Further, it is worth noting that descriptive results about high school math teachers' deficit thinking indicate that on average teachers slightly endorse a deficit view of the student. Thus, some degree of deficit thinking appears to be quite common. Descriptive analyses also revealed that male math teachers and those who have taught less than 16 years significantly endorse higher deficit beliefs compared to their female colleagues or colleges who have taught for more years. Since this study uses a cross sectional design, the data cannot speak to when the high school math teachers acquired their beliefs or why.

I argue that further work is needed on entering secondary math pre-service teachers and their deficit thinking beliefs. It may be that math teachers' experiences as students in their own math classes, their student teaching, or training in reform practices may influence their beliefs about the students they teach. Some research suggests that school climate may play a role in shaping personal beliefs about deficit thinking (Hipp & Bredeson, 1995; Lee et al., 1991; Hoy & Woolfolk, 1993). More research needs to be done on if and how their beliefs change over time and if there are critical junctures or occurrences that shape math teachers deficit thinking beliefs.

Additionally, due to this study's cross sectional nature, a causal argument cannot be made about the relationship about high school math's teacher beliefs and the use of reform pedagogical practices. It may be that reform pedagogical practices (or lack of reform practices) and the resulting student outcomes, may inform teacher deficit beliefs about students' potential for learning, which then again inform choosing or not to enact reform teaching. Some literature suggests classroom practices influence teacher's self-efficacy beliefs (Holzberger et al., 2013; Stein &Wang, 1988). For example, in s study of 155 German secondary math teachers Holzberger et al. (2013) found that instructional quality (as measured assessing students' cognitive activation during the math class, classroom management, as well as individual learning support for students) influenced teacher's self-efficacy the follow school year. Therefore, further longitudinal studies should be done to disentangle the relationship between math teacher deficit beliefs and reform pedagogical practices, and suggest a new avenue for research.

Further, multivariate results also revealed that teaching more advanced math courses are more predictive of using reform pedagogy, consistent with the tracking literature (Oakes, 1994). This literature suggests that teachers may have deficit views of students in the less advanced classes and offer less challenging work and have lower expectations. Once again this data is cross sectional and cannot disentangle the relationship between teacher beliefs, tracking and reform pedagogies or if tracking influences reform practices which then influences teacher perceptions about their students learning. If it is the later, there might be something systemic contributing to the teachers' deficit views, by seeing students in low track classes.

Teacher deficit beliefs may be detrimental to student learning and achievement as students miss out on having deeper understandings of the material and high motivation and engagement of the concepts as offered with reform practices. By understanding the relationship between practicing high school math teachers' deficit beliefs and their use of reform pedagogy, more work can be done for both pre-service and in-service teachers to challenge their beliefs about students' learning and ability to succeed. Thus while this work contributes new information about practicing high school math teachers' deficit beliefs and their use of reform pedagogy, clearly more work is needed to further understand the relationship between the two and its consequences for students and student learning.

Table 2.1. Descriptive Statistics: Means and Standard Deviations

Variable	Mean
Reform Pedagogy	3.30 (.39)
Teachers' Deficit Thinking	2.43 (.50)
Supportive Learning Communities	.053 (.99)
High Math Teacher Expectations	.039 (.97)
Math course	2.40 (.76)
Female	.61
Minority	.12
STEM Major	.40
Years Teaching	
1-5 years	.39
6-15 years	.38
16+ years	.23

n = 3,503; Standard deviations in parentheses

Table 2.2. Mean Deficit Thinking by Teacher Characteristics

TEACHER CHARACTERISTICS	MEAN ON DEFICIT		
Gender	Male		Female
	2.531***		2.368
	(0.509)		(0.486)
Race/Ethnicity	White		Minority
	2.427		2.47
	(0.492)		(0.561)
Undergraduate Major	STEM Major		Non -STEM Major
	2.423		2.439
	(0.519)		(0.490)
Years Teaching	1-5 Years	6-15 Years	16+ Years
	2.4496	2.452	2.371 **
	(0.491)	(0.499)	(0.520)
Math Course	Below Algebra	Algebra	Advanced
	2.472	2.444	2.41
	(0.489)	(0.509)	(0.495)

Standard deviations in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ~ p<.1

Table 2.3. Correlations between Deficit Thinking and School Characteristics

(n=3,503)	Teachers' Deficit Thinking	Supportive Learning Communities	High Math Teacher Expectations
Teachers' Deficit Thinking	1.0000		
Supportive Learning Communities	-0.0568	1.0000	
High Math Teacher Expectations	-0.1546	0.4762	1.0000

Table 2.4. Regression Analyses Predicting Reform Based Practices

VARIABLES	Model 1 Reform Based Practices	Model 2 Reform Based Practices
Deficit view of student	-.0878 ***	-.0562 ***
	(.0151)	(.0145)
Controls		
Female		.0276~
		(.0147)
Minority		.0393~
		(.0237)
Years of teaching experience: (*reference 6-15 years*)		
1-5 years		-.0330**
		(.0211)
16+ years		.0232
		(.0185)
STEM major		.0372**
		(.0145)
Math course (reference: algebra)		
Below algebra		-.0639**
		(.0258)
Above algebra		.0920***
		(.0149)
Supportive Learning Communities		.0503***
		(.0088)
High Math Teacher Expectations		.0992***
		(.0089)
Constant	3.512 ***	3.368 ***
	(.0152)	(.0407)

Observations: 3,503; Number of Schools: 845
Standard Errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ~ p<.1

Chapter 3: Examining High School Math Teachers' Beliefs about Student Learning and Student Math Outcomes

Introduction

Not only are students' academic outcomes an important indication of students' attainment of skills and understanding learned in school, they also have long-term implications for students' future life course. Academic outcomes serve as an important predictor of adolescents' future educational attainment, future career or professional opportunities, as well as attainment of social status and personal well being (Campbell & Mandel, 1990; Oswald, 1997). Moreover, students' math outcomes are especially important to consider as math achievement has long-term consequences for students' subsequent math course choices, college matriculation and choice of major (e.g STEM major vs not), college completion, and potential earnings (Martin, 2009; Simpkins, Davis-Kean, Eccles, 2006; Trusty & Niles, 2003). Therefore, due to its life course implications, it is important to understand predictors of students' math achievement.

There is a large body of educational literature that examines teacher beliefs and expectations and their relationship to student academic outcomes (Friedrich et al., 2015; Kuklinski & Weinstein, 2001). These beliefs and expectations are critical to study since they have implications not only for teachers' choices and actions in the classroom, but also because students may perceive teachers' perception of their competence and potential, which can then impact their engagement and experiences within the classroom (Good & Brophy, 1970; Weinstein, 2002). Previous literature has examined teacher beliefs such as self-efficacy, constructivist teaching beliefs, or expectations of student success and the implications these beliefs have on student academic outcomes (Voss et al., 2013). However, there is limited empirical research that explicitly focuses on measuring teachers' deficit beliefs, or beliefs that students' learning potential is dictated by their home environment and family background, despite the fact that much research focused on minority students and students coming from low socio-economic backgrounds invokes teachers' deficit beliefs as a likely cause of bias or inequity in the classroom (Gutierrez, 2008). Moreover, while there is a qualitative research literature that examines teacher deficit beliefs, this research does not consider potential direct links to student academic outcomes on a large scale.

This paper builds on the mostly qualitative limited research on teachers' deficit thinking and the larger literature on teacher beliefs and expectations by examining the implications of such deficit beliefs for student outcomes. Specifically, teachers holding deficit views may have limited expectations for their students and think they are not capable of achieving high standards, which may in turn impact students' academic engagement and their own beliefs in their ability, and thus ultimately impact their academic achievement. Thus, math teachers' deficit beliefs may have negative implications for students' mathematical outcomes.

Therefore, this study seeks to extend the prior research on teacher deficit beliefs and students outcomes utilizing data from the High School Longitudinal Study: 2009, a nationally representative study focusing on math and science outcomes conducted by the National Center for Educational Statistics. This dataset surveys approximately 23,000 high school 9th graders from 944 different schools. It provides an ideal opportunity to examine the longitudinal association between high school math teachers' deficit beliefs and students' 9th grade math outcomes, as students are linked in to their math teachers.

Background

What do we know about teacher beliefs and student achievement?

Teacher beliefs and expectations about their students' academic potential and acquired skills are informed by visible indicators of students' previous performance (e.g. grades), their own assessment and perceptions of students' performance, as well as teachers' and societal stereotypes. Teacher beliefs can influence student performance and achievement, as these beliefs serve as a signal to students of their likely competence (Cooper, 1979; Jussim, Eccles, Madon, 1996; Kuklinski &Weinstein, 2001; Muijs & Reynolds, 2002; West & Anderson, 1976). Drawing from the literature on teacher beliefs and expectations, this literature suggests an association between teacher beliefs and student achievement in mathematics (Calderhead, 1996; Friedrich et al., 2015; Peterson, Carpenter, Fennema, et al., 1989). For example, in a longitudinal study of 53 teachers and 496 second and third graders in Germany, Staub and Stern (2002) examined teachers' beliefs about teaching mathematics and found students whose teachers believed that students learn best through figuring out problems has larger achievement gains in math at the end of the school year. Relatedly, in a longitudinal study of 73 teachers and 1,289 fifth grade students, teacher expectations about how well students could solve different problems was gathered and both student math grades and students standardized math scores were recorded. Teacher expectations significantly predicted both standardized math scores and math grades for the fifth grade students (Friedrich et al., 2015).

However, this literature does not examine beliefs teachers have about the students' home life and their students' capabilities for learning.

Deficit Thinking

Teachers' deficit beliefs of students are particularly important to examine. Deficit thinking relates to the beliefs teacher hold about how students' background or home environment is a major obstacle to their learning capacity and success in school, particularly for minority students and students coming from low socio-economic background (Delpit, 2006; Garcia & Guerra, 2004; Valencia, 2012). Teachers holding deficit views place the blame of student underperformance on factors outside the classroom and school and lack of student success is attributed to cultural inadequacies, lack of motivation, poor student behavior, and torn apart families (Garcia & Guerra, 2004; McKenzie & Scheurich, 2004; Smit, 2012).

While there is very limited quantitative research on teachers' deficit beliefs, some qualitative studies suggest that these deficit beliefs may be detrimental to students' learning and achievement (Guerra & Nelson, 2009; Smit, 2012; Pollack, 2013). For example, McKenzie and Scheurich (2004) conducted interviews with eight white elementary school teachers working in high minority and low income school, and found that teachers with deficit beliefs had low student expectations, and were less likely to challenge students; at the same time they did not blame themselves for students' underachievement and disregarded students' learning potential. Further, qualitative work following three high school math teachers working with English language learners found that they endorsed deficit views and believed the students had lower mathematical proficiency, and subsequently avoiding assigning rigorous tasks so the students “would not get bogged down in the mathematics” (de Araujo, 2017, p. 378).

While informative, it is important to note that research suggesting a link between teachers’ deficit beliefs and student outcomes is limited in several regards. Most of the studies, especially from the qualitative deficit thinking literature, utilize very small samples or use samples of pre-service teachers or elementary school teachers whose beliefs and practices likely diverge from those of practicing teachers or from high school teachers, respectively. Moreover, studies that examine deficit thinking focus on teachers primarily in urban settings or consider teachers’ deficit thinking in relation to narrow groups of students (de Araujo, 2017; Smit, 2012). Further, many studies use a deficit thinking framework as a key part of their theoretical background when discussing inequity and bias, but not do actually measure the presence or impact of such teacher beliefs (Gutirriez, 2008). Finally, many samples used in the studies are very specialized, for example, including samples from different countries (Staub & Stern, 2002; Smit, 2012).

Therefore, this study will make a new contribution to the literature by addressing two research questions. First, does teachers’ endorsement of deficit views of student learning potential predict students’ 9th grade math grade achievement (i.e. math GPA)? Second, is this association stronger (i.e. more detrimental) for students from under-served backgrounds, such as minority youth, students with lower socio-economic status, and those in low-level math classes? To address these two questions, I will utilize a large national sample of high school students and their math teachers.

Data

Participants

The data used for this study comes from the High School Longitudinal Study (HSLS) of 2009. The HSLS is a nationally representative sample of approximately 23,000 ninth graders coming from 944 schools across the United States. The HSLS surveys students' attitudes and beliefs about mathematics as well as their algebraic reasoning and problems solving skills in both 9th and 11th grade to study students transition into postsecondary paths, with an emphasis on STEM outcomes. Baseline measures for students were collected at the beginning of the 9th grade and follow up surveys were administered in 11th grade, and high school transcripts were collected in 12th grade. Further, students' math and science teachers, along with parents and schools administrators were surveyed as part of the baseline measures to provide contextual information. The data used for this study comes from the base year student surveys and uses transcript data along with math teacher surveys. Students are linked with math teacher survey information and multiple students can be linked to one math teacher.

My analytic sample is limited to students not missing on 9th grade math GPA, who have teachers who completed the survey, and were taking a 9th grade math course, as defined by the X1STATUS variable. Students missing on race and gender as well as teachers missing on race and gender were dropped from the sample. Student socio-economic status, student math efficacy, grade 8 math grade, level of math course, teachers' years math teaching, and teachers' deficit views were imputed via multiple imputation, resulting in a final analytic sample of 14,876 ninth graders. To account for the complex survey design of the HSLS, the *svy* command in STATA was utilized to account for the primary sampling unit and the strata. Further, the analyses were weighed with the transcript weight, W3W1STUTR, and the standard errors were adjusted through Taylor expansion linearization.

Dependent Variable

The dependent variable is students' 9th grade math course grade (GPA) and is on a 4-point scale. This variable was constructed from the HSLS student transcript file and is the grade point average of the students' 9th grade math course. To create the 9th grade math GPA, first students' grade point equivalents, on a standard 0 to 4 scale, were obtained from a ordinal 13-point scale provided in the transcript file, using the documentation provided on the NCES website for HSLS. Next to account for different terms (quarters, trimesters, semester, year long), the grade point equivalent was then multiplied by the number of credits received for the class and then divided by the number of credits the student attempted.

Independent Variable and Controls

The independent variable, deficit thinking, is a scale measuring teachers' endorsement of a deficit view of student learning. It is comprised of five items, including: "the amount a student can learn is primarily related to family background"; "when it comes down to it, you really cannot do much because most of the students' motivation and performance depends on their home environment"; "if a student is not disciplined at home, they are not likely to accept any discipline at school"; "if parents would do more for their children, you could do more for your students"; and "you are very limited in what you can achieve because a student's home environment is a large influence on their achievement". Response categories ranged from 1 (strongly agree) to 4 (strongly disagree) and response were reverse recoded so that higher scores indicate more agreement with the deficit view of student learning. The alpha reliability for this scale is .75.

Several controls capture students' and teachers' background. Student controls include students' gender, race/ethnicity, socio-economic status, 9^{th} grade math self-efficacy, and self-reported 8^{th} grade math grade. Gender is a dichotomous variable distinguishing between female (1) and male students (0). Students' race/ethnicity was coded into 5 categories: Black/African American, non-Hispanic; Hispanic; White, non-Hispanic; Asian/Pacific Islander/ Hawaiian, non-Hispanic, and Multi-racial and Other, non-Hispanic. Student's socio-economic status was captured by the composite NCES created variable, X1SES, which includes measures of parental income, parental occupation and parental education. Higher values of this variable represent higher student socio-economic status. The student socio-economic variable is continuous and standardized. Further, student math efficacy is X1MTHEFF is also a composite variable created by NCES. It is created from the following 4 items related to the student 9^{th} grade math course: "You are confident that you can do an excellent job on tests in this course"; "You are certain you can master the skills being taught in this course"; "You are certain that you can understand the most difficult material presented in this course"; and "You are confident that you can do an excellent job on the assignments in this course". This variable is standardized and continuous. Eighth grade math grade is a self reported measure, where students reported the final grade of their 8th grade math course. The measure is on a 1 to 5 scale and was recoded so 1 corresponds with a grade of "below D" and 5 corresponds to a grade of an "A". Students who marked that their 8th grade class was not graded were recoded as missing. An additional control variable captures the level of the math course that the student is in, with higher values corresponding to more advanced coursework on a 3-point scale: 1 (below algebra), 2 (algebra), to 3 (above algebra). Teacher controls capture teachers' background, including gender, minority status, and years of teaching experience. Both teacher gender and minority status are dichotomous variables (for race this is due to the very low number of non-white teachers), and years of math teaching experience is a continuous variable.

Results

Descriptive Results

Table 3.1 shows the means and standard deviations of the variables. For the dependent variable, the students' 9th grade math grade point average is 2.405 on a 4-point scale, corresponding to approximately a letter grade between a B- and a C+. For the independent variable, teachers' deficit beliefs, the mean is 2.415, which indicates that the math teachers tend to slightly agree with deficit statements about a student's home life. Moving on to the student characteristics, approximately half of the students are white (56%). Students' self reported math grades from the 8th grade are relatively high, with a letter grade equivalent to a B. Moving on to the teacher characteristics, 60% of the teacher of students are female and a majority are white. Teachers on average have ten years of teaching experience, and most 9th grade students (and their teachers) are in algebra.

Multivariate results

To examine the relationship between math teachers' deficit beliefs and their students' 9th grade math GPA, school fixed effects models were used. Analyses begin with baseline models, which only include the independent variable capturing teachers' beliefs. Next multivariate models with teacher and student controls will be individually examined, and lastly the full model will be examined to determine whether deficit beliefs predict students' ninth grade math GPA net of both teacher and student controls.

Beginning with model 1, the results in table 3.2 show that teacher endorsement of a deficit view of student learning is negatively and significantly related to students' 9th grade math GPA. In model 2, with the inclusion of the teacher controls, the deficit coefficient is slightly reduced but still significant. Among the controls, we see that the level of the math course is significant, with below level algebra courses having a negative and significant coefficient indicating a reduction in 9th grade math GPA, while taking an advanced math course has a positive and significant coefficient, indicating an increase in 9th grade math GPA. Also, among the teacher controls, the female coefficient is positive and significant, indicating that compared to having a male teacher, having a female teacher is predictive of higher 9th grade math GPA.

In Model 3, we move to the student controls. The main independent variable, teachers' deficit beliefs, is still negative and significant, although the coefficient is slightly decreased from the baseline model. Among the student controls, the female coefficient is positive and significant, indicating that female students have higher 9th

grade math GPA compared to male students. Compared to white students, Black, Hispanic, and Multi-racial and other students, have a negative and significant coefficient, indicating they have lower 9th grade math GPA compared to white students. Asian students have a positive and significant coefficient, indicating higher 9th grade math GPA's compared to whites. Further, both student socio-economic status and math efficacy were significant and positive indicating that students with higher levels of socio-economic status or math efficacy, respectively, have higher 9th grade math GPA. Further, taking a more advanced math course is predictive of higher 9th grade math GPA compared to algebra. Lastly, 8th grade math grade is positive and significant, indicating that a one unit increase in 8th grade math grade leads to an increase in 9th grade math GPA.

Moving to model 4, the full model, we see that the deficit coefficient is slightly reduced but still significant with the inclusion of all the teacher and student control variables. This indicates that students whose teachers endorse high levels of deficit views have lower 9th grade math GPA. Specifically, in this final model we see that as a teacher increases in her agreement of deficit thinking, students lose almost a tenth of a grade point, net of all of the controls in the model.

Among the controls, we see that once again, that compared to males, female students have higher 9th grade math GPAs. Similarly, compared to white students, Black, Hispanic, and Multi-racial and other students, have a negative and significant coefficient, indicating they have lower 9th grade math GPA's compared to white students, while Asian students have a positive and significant coefficient, indicating higher 9th grade math GPA's compared to whites, net of both student and teacher characteristics. Further, once again both student socio-economic status and student math efficacy are significant and positive. Taking a more advanced math course remains predictive of higher 9th grade math GPA (compared to the reference category of algebra), as does higher 8th grade math grades. Lastly, if a student has a teacher who is female, they have higher 9th grade math GPA's compared to their peers with male teachers.

While the results in Table 3.2 indicate a main effect of teachers' deficit beliefs on students' math achievement, this does not address whether such beliefs might be more detrimental for certain students, such as those from under-represented or under-served backgrounds. To examine this, I conducted additional models where teachers' deficit beliefs were interacted with a) students' gender, b) students' race/ethnicity, c) students' SES, and d) students' math course level. As we see in Table 3.3, none of these interaction terms in the above sets of models were statistically significant. This indicates that there is not a multiplicative effect of deficit thinking on students' 9th grade math GPA based on student characteristics. Put differently, these results suggest that that teachers' deficit thinking does not harm certain groups of students' 9th grade math GPA more than others.

Figure 3.1 shows the predicted values of the math teachers' deficit thinking on students' math GPA's, for the average math teacher and the average ninth grader. We see that for teachers who endorse deficit views at two standard deviations below the mean (disagree strongly with a deficit view), their students have a math GPA of about 2.4, while for teachers who endorse a deficit view of two standard deviations above the mean (very likely to agree with a deficit view), their students' have a predicted math GPA of

2.2. Therefore, having a teacher with strong deficit views puts the student at a disadvantage compared to a student with a teacher who strongly disagrees with deficit beliefs.

Discussion and Conclusion

Using a large national sample of 9th grade high school students and their 9th grade math teachers, this empirical study investigates whether teachers' deficit beliefs predict students' academic outcomes. Specifically, this study examines if high school math teachers' deficit beliefs about their students' home background predict end of the year student 9th grade math GPA. Further, this research sought to examine if the effect of teachers' deficit thinking on student's 9th grade math GPA is more harmful for certain groups of students, such as students coming from low socio-economic backgrounds, racial minority backgrounds, or those enrolled in less advanced math coursework, as is suggested by the literature on deficit thinking (Bruton & Robles-Pina, 2009; McKenzie & Scheurich, 2004).

The results of this national study reveal that students with high school math teachers who endorse deficit views of student learning on average have lower 9th grade math grade point averages. The results are robust to the inclusion of a variety of both teacher and student controls including level of math course and students' 8th grade math performance, as well as teacher and student background characteristics. Therefore, while I cannot make a causal claim, there is indeed strong empirical evidence that high school math teachers' deficit beliefs have an impact on students' math achievement. These results offer a new contribution to the mostly qualitative literature on deficit thinking and the math education literature, as this relationship was found for a sample of math students and their math teachers in schools across the United States. To my knowledge, this study is the first national study to specifically examine the impact of teachers' deficit thinking on students' math outcomes.

Further, this study adds to the broader literature on teacher beliefs and student outcomes, which often examines smaller samples of students which may have different characteristics that are unique to the school or location (Friedrich et al., 2015; Staub & Stern, 2002). Additionally, much of the literature on teacher beliefs and expectations focuses on elementary school students and is not specific to mathematics (Kuklinski & Weinstein, 2001; Rosenthal & Jacobson, 1968). The extant literature is further limited due to a relative lack of control variables compared to those used in this study, such as socio-economic status, students' self-efficacy, and race/ethnicity, which are all important predictors of students math achievement (Kuklinski & Weinstein, 200l; Staub & Stern, 2002).

Moreover, the analyses here found that interactions between deficit thinking and the student characteristics of gender, socio-economic level, math course level and race, Based on some qualitative literature, there was reason to believe that those from under-served groups, such as minority students, might be more negatively impacted by teachers' endorsement of deficit beliefs than majority students (de Araujo, 2017; McKenzie & Scheurich, 2004). Yet this does not appear to be the case, as the results suggest that such beliefs have the same negative implications for all students' math performance. Specifically, a one unit increase on the deficit belief variable predicts a drop in students' math GPA by about a tenth of a point; for some students, this could make the difference between failing and passing the math class, with subsequent implications for their future math course taking (not to mention their academic self-efficacy and affect towards math).

While this study makes a new contribution to the literature, it is limited in terms of unpacking the actual mechanisms through which teachers' deficit beliefs influence students' performance. Some work suggests that classroom practices act as a mediator between teacher beliefs and student outcomes[5] (Rameriz et al., 2018). For example, Voss et al. (2013) examined teachers' mathematical beliefs, including beliefs about teaching and learning math, and found that constructivist practices acted as a mediator between teachers' beliefs and students' 9th grade performance on a math assessment. Moreover, some literature suggests the importance of examining teacher beliefs at the school level, in addition to the individual level, to see how the collective beliefs of the school environment may play a role in influencing academic achievement (Friedrich et al., 2014; Rumberger & Palardy, 2005).

Additionally, future research could compare different types of student outcomes, including standardized testing as well as grades to see if teacher deficit beliefs impact

[5] Exploratory models were done to include reform practices (as defined in the previous chapter), and it was found that both reform practices and deficit beliefs both were significant in the final pooled model for 9th grade math GPA. The coefficient for reform practice was positive and significant, indicating that higher levels of reform practices have a positive influence on 9th grade math GPA, while the coefficient for deficit practices was negative and significant indicating that endorsing higher levels of deficit thinking decrease 9th grade math GPA. In the final model with student and teacher controls, the reform practices coefficient absorbs some of the influence of deficit beliefs, suggesting a mediating effect.

some outcomes more than others. As the outcome in this study (9th grade math GPA) was in fact assigned by the same teacher whose deficit beliefs were measured, this raises the question of how much of the negative effect observed is due to students actually performing at a lower level or gaining less knowledge, or whether in fact teachers who endorse deficit beliefs on average assign lower grades to students, perhaps due to biased assessments on their part. This study can also not address whether students are consciously aware of teachers' deficit beliefs, and if so, how they perceive this and react to it. In conclusion, while this study contributes new information about high school math teachers' deficit beliefs and their impact on students' 9th grade math GPA, it raises many additional questions about the relationship between the two.

Table 3.1. Descriptive Statistics: Means and Standard Deviations

Variables	Mean	Standard Deviation
Math 9th grade GPA	2.405	1.143
Teachers' Deficit Views	2.415	.499
STUDENT CHARACTERISTICS		
Student Gender		
Male	0.505	
Female	0.495	
Student Race/Ethnicity		
Black/African American, non-Hispanic	0.095	
Hispanic	0.162	
White, non –Hispanic	0.564	
Asian, Pacific Islander	0.086	
Multi & Other	0.094	
Socio-economic status	.0714	.783
Math efficacy	.0525	.991
Math 8th grade	4.049	.977
TEACHER CHARACTERISTICS		
Teacher Gender		
Male	0.396	
Female	0.606	
Teacher Race/Ethnicity		
White	0.890	
Minority	0.110	
Years teaching	10.379	9.044
Math course	2.255	.552

Table 3.2. Regression Analyses Predicting Students' Math Achievement

VARIABLES	Grade 9 Math GPA	Grade 9 Math GPA	Grade 9 Math GPA	Grade 9 Math GPA
Teachers' Deficit Beliefs	-0.189***	-0.151***	-0.101**	-0.0896*
	(0.0458)	(0.0425)	(0.0338)	(0.0348)
Student: female			0.223***	0.224***
			(0.0239)	(0.0237)
Student: (*reference: white*)				
Black			-0.267***	-0.266***
			(0.0543)	(0.0538)
Hispanic			-0.143***	-0.142***
			(0.0421)	(0.0416)
Asian			0.348***	0.343***
			(0.0760)	(0.0739)
Multi & Other			-0.186***	-0.186***
			(0.0398)	(0.0398)
Student: SES			0.172***	0.173***
			(0.0193)	(0.0193)
Student: Math Efficacy			0.263***	0.263***
			(0.0140)	(0.0140)
Math 8th Grade			0.374***	0.373***
			(0.0198)	(0.0197)
Math course: (*reference: algebra*)				
Below Algebra		-0.227**	0.0377	0.0327
		(0.0801)	(0.0733)	(0.0732)
Advanced		0.647***	0.323***	0.324***
		(0.0444)	(0.0389)	(0.0390)
Teacher: female		0.114**		0.0763*
		(0.0438)		(0.0339)
Teacher: minority		0.0468		0.0225
		(0.0743)		(0.0641)
Teacher: years math teaching		0.00122		-0.00143
		(0.00237)		(0.00188)
Constant	2.631***	2.388***	0.844***	0.755***
	(0.110)	(0.128)	(0.140)	(0.151)

Observations: 14,876; Number of Schools: 944
Standard Errors in parentheses*** p<0.001, ** p<0.01, * p<0.05, ~ p<.1

Table 3.3. Interactions between Teachers' Deficit Beliefs and Student Characteristics

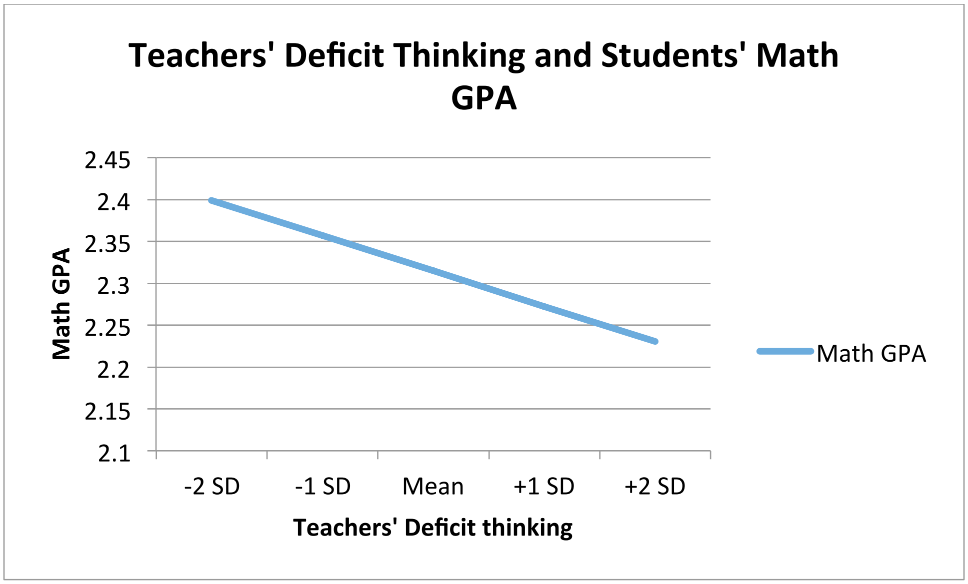
VARIABLES	Grade 9 Math GPA	Grade 9 Math GPA	Grade 9 Math GPA	Grade 9 Math GPA
Teachers' Deficit Beliefs	-0.114**	-0.0749*	-0.113**	-0.125**
	(0.0408)	(0.0364)	(0.0342)	(0.0420)
Student: female X Teachers' deficit beliefs	0.00766			
	(0.0544)			
Student: (*reference: White X Teachers' deficit beliefs*)				
Black X Teachers' deficit beliefs		-0.0826		
		(0.0819)		
Hispanic X Teachers' deficit beliefs		-0.0702		
		(0.0783)		
Asian X Teachers' deficit beliefs		0.0371		
		(0.106)		
Multi & Other X Teachers' deficit beliefs		-0.125		
		(0.0981)		
SES X Teachers' deficit beliefs			-0.0295	
			(0.0296)	
Math course: (*reference: Algebra X Teachers' deficit beliefs*)				
Below Algebra X Teachers' deficit beliefs				-0.135
				(0.121)
Advanced X Teachers' deficit beliefs				0.0836
				(0.0598)
Student: female	0.203	0.222***	0.222***	0.221***
	(0.137)	(0.0231)	(0.0230)	(0.0228)
Student: (*reference: white*)				
Black	-0.258***	-0.0564	-0.258***	-0.258***
	(0.0541)	(0.208)	(0.0540)	(0.0541)
Hispanic	-0.130**	0.0415	-0.131**	-0.131**
	(0.0411)	(0.195)	(0.0410)	(0.0413)
Asian	0.342***	0.249	0.343***	0.341***
	(0.0724)	(0.247)	(0.0728)	(0.0719)
Multi & Other	-0.192***	0.117	-0.191***	-0.192***
	(0.0398)	(0.244)	(0.0399)	(0.0398)

Table 3.3 (cont)

Student: SES	0.176***	0.176***	0.249**	0.176***
	(0.0190)	(0.0188)	(0.0757)	(0.0190)
Student: math efficacy	0.260***	0.261***	0.260***	0.260***
	(0.0136)	(0.0135)	(0.0135)	(0.0135)
Math 8th grade	0.376***	0.375***	0.375***	0.375***
	(0.0195)	(0.0194)	(0.0195)	(0.0192)
Math Course: (*reference: Algebra*)				
Below Algebra	0.00494	0.00468	0.00400	0.340
	(0.0663)	(0.0667)	(0.0663)	(0.298)
Advanced	0.308***	0.307***	0.308***	0.103
	(0.0334)	(0.0332)	(0.0334)	(0.142)
Teacher: female	0.0732*	0.0733*	0.0735*	0.0728*
	(0.0342)	(0.0342)	(0.0342)	(0.0342)
Teacher: minority	0.00949	0.00740	0.0100	0.00730
	(0.0650)	(0.0652)	(0.0652)	(0.0649)
Teacher: Years math teaching	-0.000955	-0.000980	-0.000963	-0.000855
	(0.00190)	(0.00190)	(0.00189)	(0.00190)
Constant	0.818***	0.726***	0.816***	0.848***
	(0.151)	(0.127)	(0.135)	(0.155)

Observations: 14,876; Number of Schools: 944
Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ~ p<0.10

Figure 3.1. Predicted Values of Students' 9th Grade Math GPA



Conclusion

Educating all students to be literate and critical thinkers in the STEM fields is on the forefront of the current discussion in education. Further, attracting all students, particularly students from underrepresented groups, to enter into the STEM fields is critical to meet the shortages in certain fields of engineering, data science, and software development (Xue & Larson, 2015). Moreover, it is important to continue to investigate why some students have more success in the STEM fields while others do not. Extant theory and prior empirical research strongly suggest that educational beliefs, both on the part of students and their teachers, are an important part of the complex set of factors that help to explain why some students are more successful in the STEM fields (Dweck, 2008; Eccles et al., 1983; Multon, Brown & Lent, 1991; Wigfield et al., 1991). Therefore, this dissertation contributes to this conversation about educational beliefs related to STEM with three analytic chapters using two large nationally representative samples of students and teachers from the United States.

The first analytic chapter examines the relationship between the student beliefs of mindset, math confidence, and math anxiety and gives us a clearer picture of the relationship between these beliefs. Results show that mindset can be broken up into two distinct factors, a more general belief referring to students' mindset about their intelligence in general, and a more domain specific belief, math mindset, which is the students' belief about their math intelligence as malleable or innate. Further, results indicate that both general and math mindset are distinctly different than math confidence and math anxiety. The analyses also reveal that math confidence has a stronger association with academic math performance than the other three beliefs. However, more work needs to be done to disentangle the factors that predict general mindset, math mindset, and math anxiety as they might be more influenced by cultural beliefs and stereotypes than actual feedback from teachers regarding academic performance. Stepping back, relatively few prior studies examine mindset in subject specific domains such as math, science, or engineering (Hendricks, 2012) and none of the studies reviewed examined the relationship between all three constructs; therefore this chapter contributes to this limited body of literature. Further, the findings contribute to our understanding of the relationship regarding gender and mindset, as there is no clear consensus regarding differences in the existing literature, and advance our understanding of the relationship between gender across the four different beliefs. Further, girls endorse more fixed math mindsets, have less math confidence, and more math anxiety compared to boys. Additionally, when comparing all these beliefs the biggest gender gap occurred with math anxiety, with smaller differences in fixed math mindset and math confidence, and no significant gender gap in fixed general mindset. While this chapter does not follow students as they progress through high school and into college, insights from prior research suggest that these gender differences have implications for women's underrepresentation in STEM fields. Future longitudinal research could work to unpack whether and how gaps in these beliefs change as students progress, and which beliefs may be most consequential for explaining subsequent gaps in choice of college majors.

The second analytic chapter contributes to our understanding of high school math teachers and their endorsement of deficit beliefs. High school math teachers, on average, are likely to slightly agree that students' home backgrounds limit their ability to learn. Male teachers and teachers who have taught for less than 16 years agree more with deficit views compared to female teachers and teachers who have taught more than 16 years. Surprisingly, teachers' deficit beliefs are consistent across different levels of math courses. This is the first study to examine high school math teachers' deficit beliefs from across the United States, but more research needs to be done as this current study does not tell us why or how these beliefs developed, due to the study's cross sectional nature.

Secondly, this chapter examines the relationship between deficit beliefs and reform practices and finds that teachers who endorse more deficit views are less likely to engage in reform teaching practices. This is the first national study that examines the relationship between teachers' deficit thinking and reform pedagogy. While the previous existing quantitative literature examines teachers' general teaching efficacy, the samples used in those studies were very specialized, for example, including teachers from only religious schools or special education teachers and are not representative of all teachers (Woolfolk et al., 1990; Soodak & Pollack, 1994). Additionally, the previous studies examine aspects of teacher classroom behavior (which can be associated with pedagogical practices), such as autonomy or a bureaucratic approach, but do not examine the pedagogical practices used in the classroom (Woolfolk et al., 1990). Further, most of the studies, especially coming from the qualitative deficit thinking literature, utilize very small samples or use samples of pre-service teachers or elementary school teachers whose beliefs and practices likely diverge from those of practicing teachers or from high school teachers, respectively. Moreover, this study finds that math teachers' endorsement of deficit views of student learning predicts less of an emphasis on reform based pedagogical practices. This may have implications for student learning and outcomes as students whose teachers endorse deficit views miss out on the benefits of reform practices such as having a deeper understanding of the material, better grades, and more confidence in their math abilities (Boaler, 1998; Geier et al., 2008; Krajcik et al., 1998; Petrosino et al., 2003), which may lead to implications about which students succeed in math and choose to go into the STEM fields.

Further, building upon the first and second analytic chapter, the third analytic chapter examines the relationship between teacher beliefs and students' academic outcomes. I find that net of a host of control variables, being taught by a teacher with a higher level of endorsement of deficit beliefs is related to a decrease in students' 9th grade math GPA. This effect applies equally to all students; surprisingly, teacher deficit views are not more harmful for students coming from underserved backgrounds, such as those from lower socio-economic status or having racial minority backgrounds. Given that math performance in early high school is predictive of later math achievement, as well as predictive of choices to enter STEM fields in college (Ellington, 2006; Ethington &Wolfle, 1988; Maple & Stage, 1991; Wang, 2013), it is possible that teachers' deficit beliefs may have far reaching negative consequences. Although it was not measured in this study, it is possible that students with teachers who have strong deficit beliefs may also receive messages that the teacher does not think they are capable of mastering the material, which may influence their beliefs about themselves. This may impact their own thinking and decisions about whether or not they should enter into the STEM fields.

Therefore, more longitudinal work needs to be done to better understand the consequences of teachers' deficit views on student beliefs and also students' decisions about entering into the STEM fields.

By using two national datasets, this dissertation was able to contribute new information about teacher and student beliefs regarding math. While results did document important and robust associations between teachers' beliefs and their pedagogical practices, and teacher beliefs and student outcomes, neither dataset provided a good opportunity to examine how teacher beliefs may predict students' subsequent STEM-related beliefs. And while the national datasets provide the opportunity to more easily generalize findings across schools and classrooms in the United States, they have more limited utility in being able to unpack the actual mechanisms at work behind the patterns documented here. Future research should continue to address the complex ways in which beliefs impact the STEM-related choices and behaviors of both students and teachers, and the relationship between them.

Appendix

Table A.1. Gender- Race Interactions for Mindset, Confidence, and Math Anxiety

VARIABLES	Model 1 Fixed General Mindset	Model 2 Fixed Math Mindset	Model 3 Math Confidence	Model 4 Math Anxiety
Female	0.0564**	0.140***	-0.179***	0.424***
	(0.0218)	(0.0239)	(0.0217)	(0.0238)
Black	0.0770*	0.0744	0.190***	0.0274
	(0.0370)	(0.0406)	(0.0369)	(0.0404)
Hispanic	0.0449	0.0103	0.0313	0.0128
	(0.0321)	(0.0353)	(0.0321)	(0.0351)
Asian	0.00618	-0.0612	0.133*	-0.0633
	(0.0541)	(0.0594)	(0.0539)	(0.0591)
Multi & Other	0.0769**	0.0205	0.0294	0.0380
	(0.0264)	(0.0290)	(0.0263)	(0.0288)
Female x Black	0.0670	0.0772	-0.147**	-0.0994~
	(0.0489)	(0.0537)	(0.0488)	(0.0534)
Female x Hispanic	0.104*	-0.0248	-0.0476	-0.0121
	(0.0420)	(0.0462)	(0.0419)	(0.0459)
Female x Asian	0.111	-0.0199	-0.0699	-0.00602
	(0.0770)	(0.0847)	(0.0768)	(0.0842)
Female x Multi & Other	-0.0468	-0.0104	-0.0141	0.0201
	(0.0371)	(0.0407)	(0.0370)	(0.0405)
Mother's Education	-0.0105*	0.00372	0.0201***	0.00421
	(0.00501)	(0.00551)	(0.00500)	(0.00548)
Academic Variables				
Grades	-0.129***	-0.134***	0.474***	-0.157***
	(0.00948)	(0.0104)	(0.00945)	(0.0104)
Reference: Algebra				
Below Algebra	0.133***	0.101**	-0.0745*	0.0430
	(0.0293)	(0.0322)	(0.0292)	(0.0320)
Advanced	-0.0981***	-0.0721***	0.161***	0.101***
	(0.0187)	(0.0206)	(0.0187)	(0.0205)
Additional Controls				
Missing for Mother's Education	0.164***	0.0477*	-0.00157	-0.0812***
	(0.0194)	(0.0214)	(0.0194)	(0.0212)
Missing for grades	0.134	0.219	-0.557***	0.247
	(0.154)	(0.169)	(0.153)	(0.168)
Missing for math course	0.00771	0.00397	-0.0380	0.0856**
	(0.0242)	(0.0266)	(0.0241)	(0.0264)
Constant	0.485***	0.456***	-1.979***	0.373***
	(0.0434)	(0.0477)	(0.0433)	(0.0475)
R-squared	0.039	0.024	0.204	0.055

Observations: 14,783; number of schools: 75

Standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Figure A.1. Predicted Fixed General Mindset

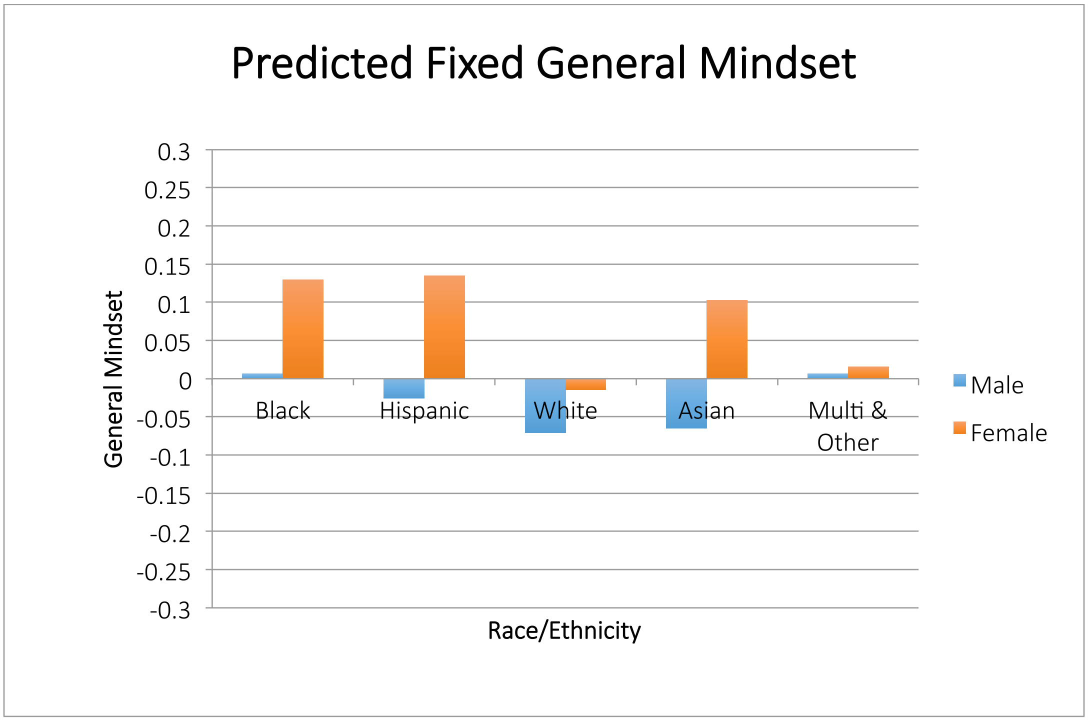


Figure A.2. Predicted Fixed Math Mindset

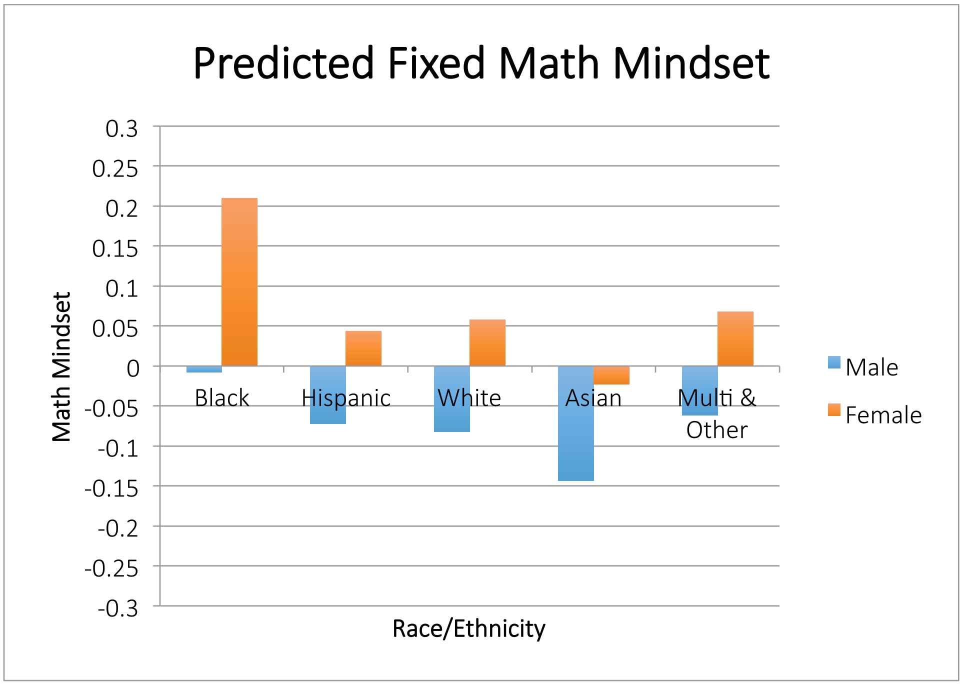


Figure A.3. Predicted Math Confidence

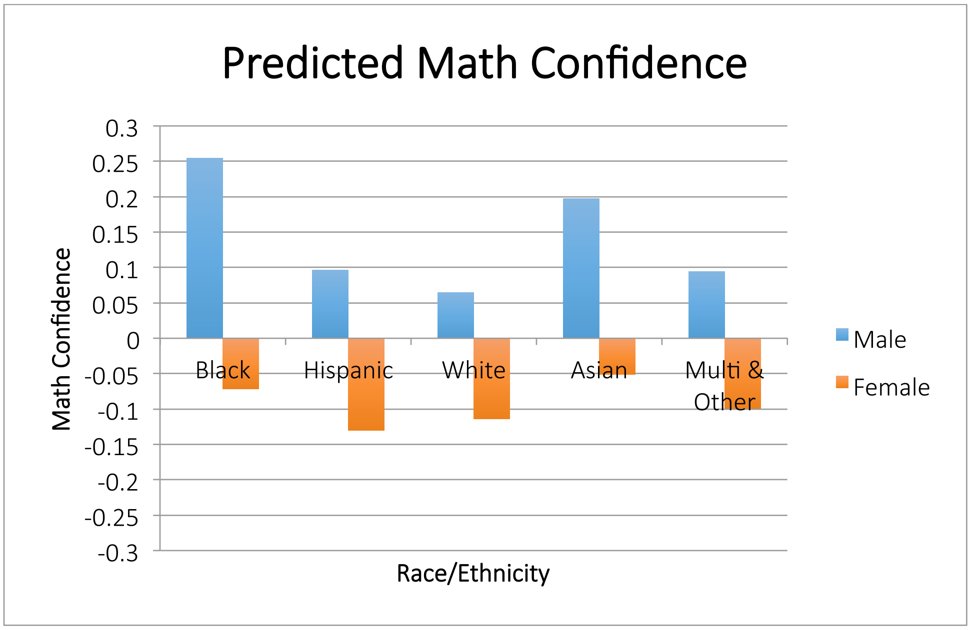
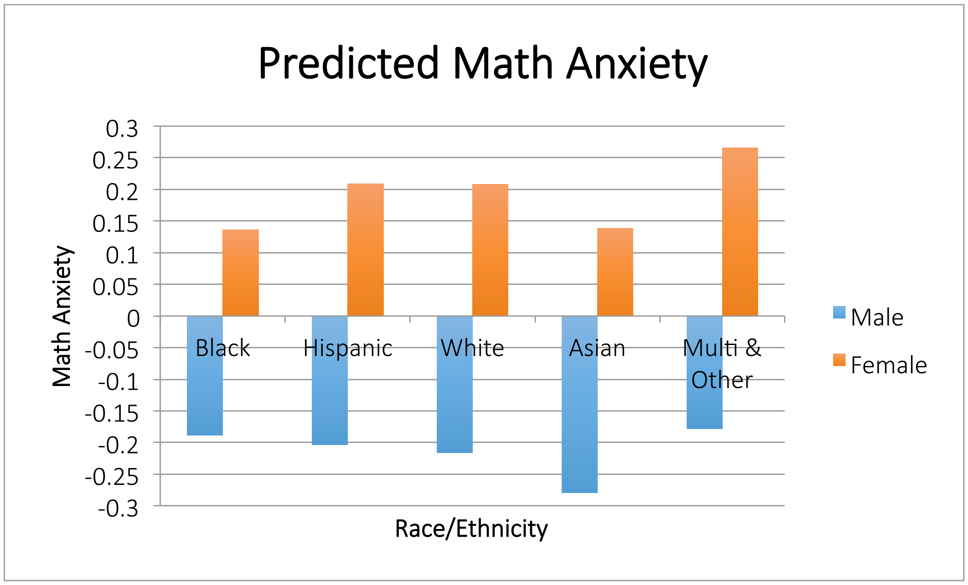


Figure A.4. Predicted Math Anxiety



Reform Based Pedagogical Practices

How much emphasis do you place on the following…

M1INTEREST	Increasing students' interest in mathematics
M1CONCEPTS	Teaching students mathematical concepts
M1IDEAS	Teaching student how mathematics ideas connect to one another
M1PROBLEM	Developing students' problem solving skills
M1REASON	Teaching students to reason mathematically
M1PREPARE	Preparing students for further study in mathematics
M1LOGIC	Teaching students the logical structure of mathematics
M1HISTORY	Teaching students about the history and nature of mathematics
M1EXPLAIN	Teaching students to explain ideas in math effectively
M1BUSINESS	Teaching students how to apply mathematics in business and industry

Math Learning Professional Communities (Supportive Learning Communities)

To what extent do you agree or disagree with each of the following statements about the math department at your school? Math teachers in this department …

M1SHRIDEAS	Share ideas on teaching
M1WORKSHOP	Discuss what was learned at a workshop or conference
M1SHRSTWRK	Share and discuss student work
M1SHRLESSONS	Discuss particular lesson that were not very successful
M1SHRBELIEFS	Discuss beliefs about teaching and learning
M1SHRMTHDS	Share and discuss research on effective teaching methods
M1SHRELL	Share and discuss research on effective instructional practices for English language learners
M1SHRAPPRCH	Explore new teaching approaches for under-performing students
M1SHRCONTENT	Make a conscious effort to coordinate the content of courses with other teachers at the school
M1EFFECTIVE	Are effective at teaching students mathematics
M1MENTOR	Provide support to new mathematics teachers
M1CHAIR	Are supported and encouraged by the math department's chair or curricular area coordinator

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